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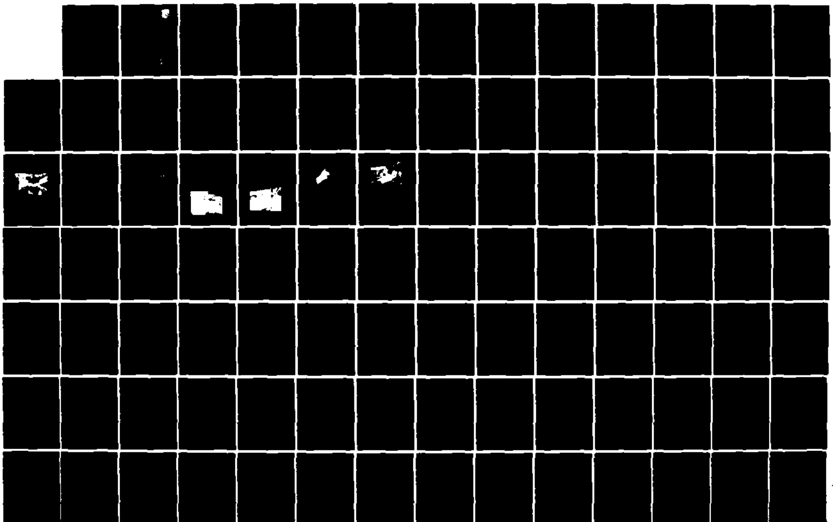

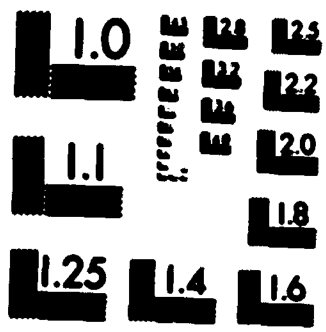

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SEPTEMBER 1984

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FLIGHT DYNAMICS LABORATORY
AIR FORCE WRIGHT AERONAUTICAL LABORATORIES
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433

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This technical report has been reviewed and is approved for publication.

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The use of uncoupled, six-degree-of-freedom (6-DOF) motion is rapidly becoming state-of-the-art in terms of necessary flight control laws and aerodynamic capability. The next generation of aircraft may use uncoupled, 6-DOF control capability in conjunction with other new technologies such as Integrated Flight-Fire Control (IFFC). In order for these future applications of 6-DOF control to be successful, the pilot must be able to command motion and acceleration magnitudes with sufficiently good system response characteristics to accomplish particular missions or tasks.

The objective of this effort was to develop design criteria and gather appropriate substantiating data for cockpit control devices for 6-DOF motion which will assure compatibility among the pilot, control device(s) and aircraft response and will thus allow efficient implementation of the 6-DOF control capability. The effort was divided into two phases. Phase I consisted of defining existing data on the design of cockpit controllers for 6-DOF

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motion. The application of 6-DOF aircraft motion to aircraft mission requirements was examined. A set of tentative criteria was formulated and test plans developed to gather data necessary to validate and expand the tentative criteria. Following Air Force approval, a simulation was conducted using the motion-based simulator at Wright-Patterson Air Force Base. The results of the simulation were combined with the results of the literature survey to form a set of design guidelines.

Volume I of this report presents the results of the literature survey, summarizes the simulation effort and presents the design criteria. Volume II is a detailed discussion of the simulation and the analysis of the data. The appendices are also included in this Volume.

FOREWORD

The work reported herein was performed during the period from August 1981 to April 1984 under contract F33615-81-C-3605 from the Air Force Wright Aeronautical Laboratories, Air Force Systems Command. The work was completed under Project 2403, Task 05 and submitted April 1984.

The author wishes to express his gratitude to Carl R. Seavers of McDonnell Aircraft Company and R. Wade Allen of Systems Technology Inc. for their assistance in completing the Phase I literature review and mission effectiveness studies. Their efforts were essential to the successful completion of Phase I and in establishing the guidelines for the Phase II simulation.

The Phase II simulation was conducted on the Large Amplitude Multimode Aerospace Research Simulator (LAMARS) operated by the Control Synthesis Branch of the Air Force Wright Aeronautical Laboratories with the support of Lear-Siegler, Inc. The personnel of these groups are to be commended for their cooperation and hard work. In particular the author would like to recognize Jim Zeh and Cal Dyer for their efforts. The pilots for the simulation were drawn primarily from the 4950th Test Wing at Wright-Patterson AFB. The efforts of Lt. Col. Bart Tucker in scheduling pilots were greatly appreciated.

The author is grateful for the assistance and support of Wayne Jewell, of Systems Technology Inc., during the simulation. Mr. Jewell was instrumental in defining the target motion and atmospheric disturbances and in conducting the spectral analysis of the time history data.

Another group to be recognized are those individuals who served as contract monitors for this effort. Each applied his own unique talents to the problems as they arose. These individuals were Tom Cord, Lt. John Evans and the final monitor, Tom Gentry.

The author would also like to thank John Caton and Bill Moran and the other individuals at McDonnell Aircraft without whose assistance and support this report would not have been possible.

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SUMMARY

The use of uncoupled, six-degree-of-freedom (6-DOF) motion is rapidly becoming state-of-the-art in terms of necessary flight control laws and aerodynamic capability. The next generation of aircraft may use uncoupled, 6-DOF control capability in conjunction with other new technologies such as Integrated Flight-Fire Control (IFFC). In order for these future applications of 6-DOF control to be successful, the pilot must be able to command motion and acceleration magnitudes with sufficiently good system response characteristics to accomplish particular missions or tasks.

The objective of this effort was to develop design criteria and gather appropriate substantiating data for cockpit control devices for 6-DOF motion which will assure compatibility among the pilot, control device(s) and aircraft response and will thus allow efficient implementation of the 6-DOF control capability. The effort was divided into two phases. Phase I consisted of defining existing data on the design of cockpit controllers for 6-DOF motion. The application of 6-DOF aircraft motion to aircraft mission requirements was examined. A set of tentative criteria was formulated and test plans developed to gather data necessary to validate and expand the tentative criteria. Following Air Force approval, a simulation was conducted using the motion-based simulator at Wright-Patterson Air Force Base. The results of the simulation were combined with the results of the literature survey to form a set of design guidelines.

Volume I of this report presents the results of the literature survey, summarizes the simulation effort and presents the design criteria. Volume II is a detailed discussion of the simulation and analysis of the data. The appendices are also included in Volume II.

SECTION I

INTRODUCTION

The objective of this effort was to develop design criteria and gather appropriate substantiating data for cockpit control devices for six-degree-of-freedom (6-DOF) uncoupled aircraft motion. These criteria are in a form compatible with the proposed MIL-STANDARD and HANDBOOK-Flying Qualities of Air Vehicles. The proposed criteria are described in Volume I of this report.

The effort was divided into two phases. Phase I consisted of defining existing data on the design of cockpit controllers for 6 DOF motion and on the application of 6-DOF motion to aircraft mission requirements. A major portion of the Phase 1 effort was an extensive survey of existing information. This review covered all classes of aircraft except helicopters and V/STOL aircraft. The results of the literature review are summarized in Section II of this volume.

The information collected during Phase I was interesting and potentially useful in planning further research. However, attempts to develop criteria based on the available literature were hampered by the myriad of different controllers used in these studies. Often the controller characteristics were not described in any detail since the experiments were aimed at proving the viability of uncoupled control rather than the desirability of the controller. Additionally, continued reference to the inadequacy of the controllers in some of the references indicated a need for further research in the design of uncoupled motion controllers.

For these reasons, Phase 2 of this effort was a motion-base simulation to collect data specifically on the effects of certain variations of controller characteristics. Section II of this volume covers the preparation, conduction, and analysis of the data from this simulation. The simulation concentrated on fighter response characteristics and tasks since these seemed to cover the largest range of potential application of uncoupled motion control. Subsection 14 of Section II comments on the simulation in general.

Some explanations and definitions of uncoupled, 6-DOF aircraft motions are appropriate:

Mode as used herein defines the type of aircraft response to a commanded input by the pilot. Most of the modes discussed here have been examined in ground-based or in-flight simulations.

Conventional aircraft control is achieved by controlling the moments about three axes (roll, pitch and yaw) and the force along the body axis (thrust/drag modulation). Motion in the two remaining axes is achieved by using the airframe response to

moments controllable by the pilot, such as bank-to-turn, lift due to angle of attack, and side force due to sideslip. Control implementation schemes have been developed to allow control of forces in the vertical and lateral axes. These additional degrees of freedom provide several new control modes. These added modes are identified by the parameters held constant.

a. Longitudinal Modes -

- Vertical path control - Normal load factor (vertical acceleration control) at constant angle of attack.
- Vertical translation - Vertical acceleration/velocity control at constant attitude.
- Fuselage elevation aiming - fuselage angle of attack control at constant load factor.
- Drag Modulation - Velocity control at a constant thrust setting.
- Maneuver Enhancement - Blending of conventional and either vertical path control or vertical translation to provide quicker response and/or improved ride quality.

b. Lateral Modes -

- Lateral translation - Lateral acceleration/velocity control without yaw rotation or roll motion (i.e. constant heading).
- Wings level turn - Heading control with no sideslip or roll attitude motion.
- Fuselage azimuth aiming - azimuth angle control with no lateral load factor.

SECTION II

CONTROLLERS FOR UNCOUPLED MOTION SIMULATION

The objective of this simulation was to gather additional substantiating data in order to develop design criteria for cockpit control devices for uncoupled aircraft motion. Based on the extensive review of manual control and uncoupled aircraft motion carried out in Phase I of this study and on comments and suggestions from pilots and engineers within the industry, the basic issues addressed by this simulation were:

- Use of additional controllers mounted on the "Conventional" flight path controller as opposed to remote or separate controllers
- Effects of tasks on uncoupled motion controller characteristics
- Interaction of conventional flight path controllers characteristics and the uncoupled motion controllers
- Influence of motion disturbances on the pilot-aircraft interfaces
- Use of thumb and finger isometric controllers as single axis devices rather than as dual axis controllers.

For this simulation, these issues were to be addressed using methods identified in the literature. These analysis tools included task performance scores, spectral analysis, workload assessment, and pilot subjective ratings for a number of different controllers in a variety of environments.

1. STUDY PLAN CONSIDERATIONS - Taken in their broadest context, the objectives outlined above result in an almost infinite test matrix of modes, controllers, and tasks. The knowledge and experienced gained during Phase I of this effort was used to determine those areas of greatest interest. This knowledge, combined with the normal constraints of time and resources, served to reduce the matrix to a tractable form.

The reduction began first by examinimg the modes found useful in the literature. These include longitudinal and lateral modes such as:

Longitudinal Modes

- Vertical Path Control (VPC) - Normal load factor control at constant angle of attack
- Vertical Translation (VT) - Vertical acceleration/ velocity control at constant aircraft attitude

- o Fuselage Elevation Aiming (FEA) - Fuselage angle of attack control at constant load factor

- o Drag Modulation (DM) - Velocity control at constant thrust setting

- o Maneuver Enhancement (ME) - Blending of conventional and uncoupled responses to provide quicker response and/or improved ride qualities

<u>Lateral Modes</u>

- o Wings Level Turn (WLT) - Heading control with no sideslip or roll attitude change

- o Lateral Translation (LT) - Lateral acceleration/velocity control without yaw rotation or roll motion

- o Fuselage Azimuth Aiming (FAA) - Azimuth angle control with no lateral load factor.

After reviewing this list, drag modulation and maneuver enhancement were eliminated from consideration for the simulation. Maneuver enhancement usually combines conventional and uncoupled response on a normal flight controller. Specification of controller requirements for this mode are probably best covered by the existing conventional sections of the MIL-STANDARD. Drag modulation is a mode which may be very useful; however, it does not lend itself to flying qualities evaluation using the same tasks and methods as the other uncoupled modes. These modes should be examined in a future effort.

When reviewing the literature, it becomes apparent that when longitudinal and lateral uncoupled modes are examined simultaneously, the lateral modes stand out as having the greatest potential application. The longitudinal axis of an airplane is by far the most powerful axis. It is used to change the aircraft pitch attitude and altitude. It is also the prime motivator in changing aircraft heading. However, using the longitudinal axis to change heading first requires that the aircraft be rolled to put the lift vector in the necessary orientation. If a constant altitude is desired (i.e., a level heading change), then the pilot must blend longitudinal control force with aircraft roll attitude. Estimation of the proper lead is also necessary to ensure that the aircraft can be stopped (i.e., rolled out) on the desired heading.

The lateral uncoupled modes provide the pilot with a means of controlling aircraft fuselage heading and flight path direction, separately or combined, by manipulation of one device in the cockpit. This greatly simplifies the pilot heading control over the range of authority available.

For this reason, it was decided to limit this simulation primarily to investigation of controllers for the lateral modes. A limited evaluation of controllers for vertical translation in an approach and landing task was conducted, however. The use of vertical translation in this task had shown potential benefit for control of touchdown dispersion in precision landing tasks.

The next simplification was made by a decision to concentrate on Class IV aircraft and tasks. This was felt to cover the widest range of uncoupled motion application, including weapon delivery, while also covering the area where uncoupled motion would be useful for other aircraft, i.e., approach and landing. Two tasks were considered which would be applicable to other class aircraft. These included terrain following/terrain avoidance and low altitude parachute extraction of cargo from airlift craft. While interesting, it was felt that these tasks would be best left to future specialized efforts.

The remaining area of the simulation test plan to be considered included exactly what controllers to examine and what characteristics to consider. Seven basic considerations of aircraft controller design were identified in the literature review. These included:

(1) Force-displacement characteristics - The amount of displacement for a given force, (e.g., nonlinear gradients, breakout forces, force limits)

(2) Force feedback and trim cuing - Control system and surface forces reflected at the controller (e.g., parallel vs. series trim systems, stick shakers, motion stops)

(3) Harmonization - The relative force displacement characteristics between control axes (e.g., lateral versus longitudinal stick force levels)

(4) Controller Input - Aircraft response characteristics - The amount of aircraft response (pitch rate, normal acceleration, etc.) for a given input to the controller by the pilot (force, deflection).

(5) Motion coupling and disturbance - Aircraft motions which inertially couple into control axes or interfere with the pilots manipulation (e.g., bobweight effects producing control cues and commands)

(6) Controller/display relationship - The relationship between controller actions and display response (e.g., controller logic versus outside-in or inside-out display)

(7) Static anthropometric controller characteristics - The physical size and location of the manipulator with respect to the pilot (e.g., circumference of the controller compared with the pilot's hand size).

The first four of these areas are dependent on some knowledge of the input-output relationships that are acceptable to the pilot. These include the mechanical controller characteristics of breakout force and force-deflection, as well as pilot input/aircraft response relationships of deadband and maneuver gradient. The maneuver gradient is defined as the ratio of the change in pilot input to the change in aircraft response. Without knowledge of the preferred input-output relationships and the maximum authority required for the task, the designer has little idea of what range of force and displacment characteristics are required for his design.

There are an infinite number of combinations of maneuver gradient and uncoupled mode authorities which could be examined, particularly if you consider dual gradients. With dual force-deflection and/or maneuver gradients, it is necessary to define the breakpoint and degree of slope change. In order to determine these characteristics, the designer must have some knowledge of the preferred gradients for fine tracking to define the inner slopes. In addition, he must know at what authority level to change from a tracking gradient to a steeper acquisition gradient. For this simulation, it was decided to concentrate on linear gradients, which would be useful for mainly fine tracking requirements and not gross acquisition.

The fifth consideration on this list, motion coupling and disturbance, was addressed during the simulation. The mechanization and results of these studies will be illustrated in a later section. Items (6) and (7) were not experimental variables in this simulation. However, pilot comments and suggestions were collected on the head up display (HUD) format and controller size, shape, and location in the cockpit.

The selection of controllers for the simulation was based on devices identified in the literature survey and on availability and time constraints. It is felt that the controllers chosen represent a cross section of previous experience and recent developments in controller hardware. In keeping with current trends in aircraft control system and cockpit design, a sidestick controller was chosen as the primary conventional response controller. The controller is similar to those used in recent advanced helicopter simulations (References 56 and 71) and incorporates two additional control axes. The sidestick can be twisted about its vertical axis or heave inputs can be made by applying forces along the vertical axis. The sidestick also has a thumb operated miniature joystick, mounted on top of the stick grip, which provides additional control input capability. Other controllers used in the simulation included rudder pedals, a thumbwheel operated by the pilot's left hand, and a twist throttle similar to the one used on the AFTI/F-16 (Reference 51). A detailed description of these controllers appears in Section 3.

The controller characteristics which were examined are shown in Figure 1. For the rudder pedals, both the force-deflection and input-output relationships were varied. For the remaining controllers, the force-deflection characteristics were fixed and the input-output relationships were varied.

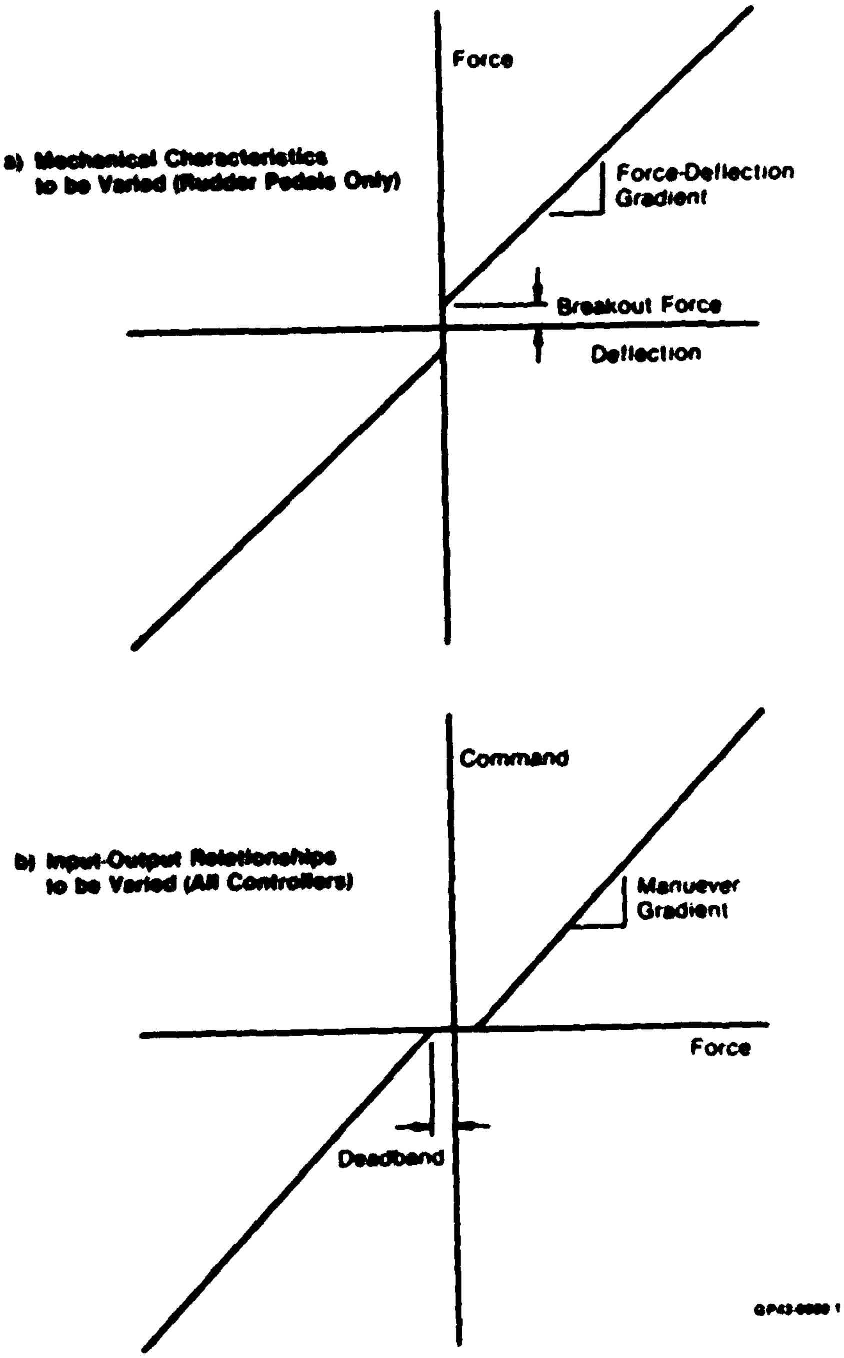

Figure 1. Controller Characteristics to be Examined

2. <u>SIMULATOR DESCRIPTION</u> - The simulation was conducted on the Large Amplitude Multimode Aerospace Research Simulator (LAMARS) at Wright-Patterson AFB, Dayton, Ohio. LAMARS, shown in Figure 2, consists of a five degree-of-freedom beam type motion system which carries a single-place cockpit enclosed by a spherical display dome on the end of a 30 foot beam.

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Figure 2. LAMARS Motion-Base Simulator

The visual display system uses the inside of the 20 foot diameter dome as a wide angle spherical projection screen. A sky-earth projector and a target projector provide the pilot with a visual representation of the outside environment. The display provides a 266° field-of-view in the horizontal plane and 108° in the vertical plane for the sky-earth presentation. A terrain board system was used to project a 45° wide by 36° high detailed terrain image for simulation tasks at low altitude. The cockpit design is compatible with all modern fighter aircraft configurations and can be readily adapted to different configurations.

The motion system is used to provide onset cues at the pilot station in direct proportion to those experienced in actual flight. Beam lateral and vertical travel is limited to ±10 feet with instantaneous acceleration limits of ±3 g's vertically and ±1.65 g's laterally. Sphere pitch, roll, and yaw rotations are limited to ±25 degrees. Maximum angular accelerations are ±400, ±460, and ±200 degrees per second squared in pitch, roll, and yaw, respectively.

The air-to-ground weapon delivery and approach and landing tasks utilized the terrain board system. This system consists of two illuminated three-dimensional terrain models. Each model is equipped with its own gantry-supported, optical-probe equipped television camera positioned by computer controlled servos. Each model, mounted vertically, is 15 feet high by 47 feet long and includes scale models of hills, deserts, rivers, lakes, and urban and rural terrain. One model represents an area 11 by 36 nautical miles (1:5000 scale). The other model represents a subsection of the 1:5000 board which is 3 by 11 nautical miles (1:1500 scale). The area duplicated on the two boards includes an airport complex complete with strobe and approach lights, airport traffic control lights, and full category II lighting. The viewing area is continuous in heading and roll but limited to 24 degrees nose up and 47 degrees nose down in pitch and yaw and 300 degrees per second in roll. The maximum angular accelerations are 300 degrees per second squared in pitch and yaw and 500 degrees per second squared in roll.

3. CONTROLLERS - The general cockpit layout is shown in Figure 3. The controllers examined during this simulation included rudder pedals, a 4-axis sidestick controller incorporating twist and heave as additional inputs, a thumb operated controller mounted on the sidestick, and a twist throttle grip similar to that on the AFTI/F-16. Additionally, some testing was done in the landing configuration using a thumbwheel mounted on a grip on the left hand side of the cockpit.

The 4-axis sidestick and the thumb operated miniature joystick provided an output proportional to the applied force. The force-deflection characteristics for these controllers were fixed. The pitch and roll axes of the sidestick had force-deflection gradients of approximately 40 pounds per inch with a maximum displacement of .4 inches at the grip center. The twist and heave axes were stiff enough that the pilots could not detect their presence when only conventional control responses were commanded. The twist force-deflection gradient was 12.0 inch-pounds of torque per degree of deflection with a 4 degree maximum deflection each side of neutral. The heave axis has a maximum deflection of ±.1 inch about neutral with a force-deflection gradient of 320 pounds per inch. The breakout forces in all axes were essentially zero.

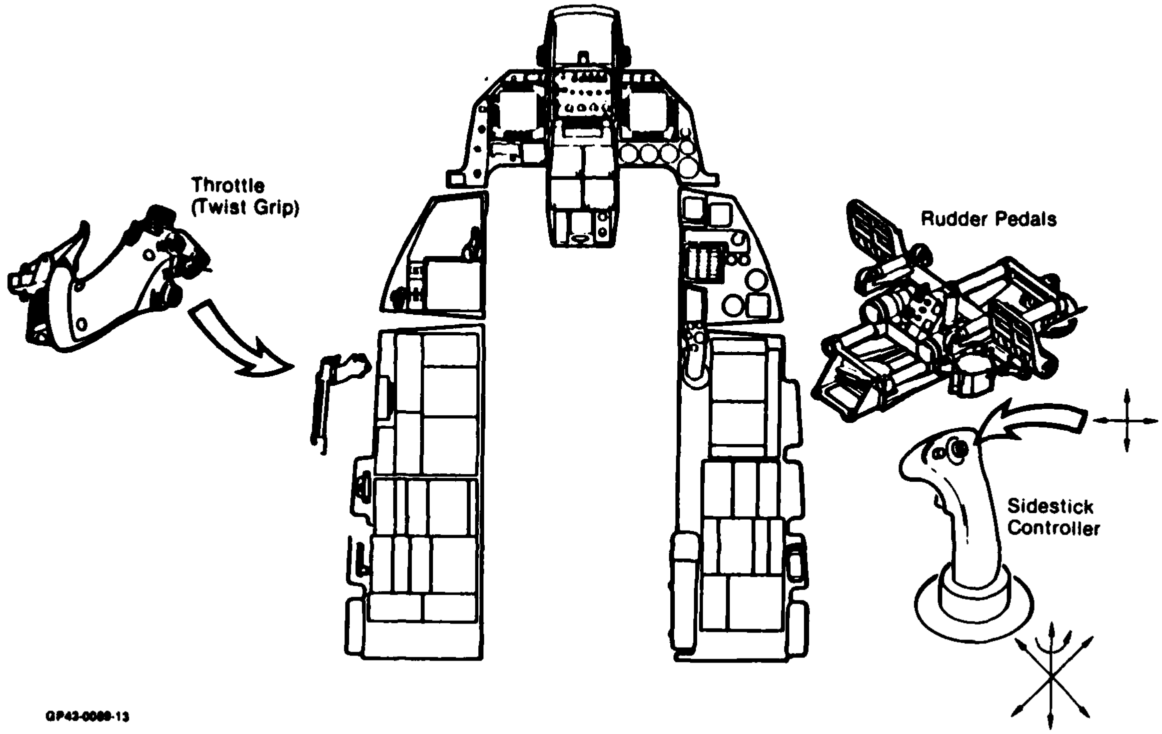

Figure 3. Cockpit Controller Location

The thumb operated miniature joystick, or thumb button controller, was mounted on top of the stick grip. The pilot would command an input by applying a force with his thumb on an inverted coolie-hat button. Maximum force was 5 pounds with a maximum deflection of approximately .06 inch, nearly isometric in appearance to the pilot. Figure 4 illustrates the control grip. Also shown are possible control modes which could be implemented on each of the control axes.

Past experience with sidestick controllers had indicated the desirability of an armrest, both for steadying the pilot's arm and providing pilot workload relief. For this simulation an adjustable armrest was provided. The sidestick and armrest installation on the right cockpit console are shown in Figure 5. Depending on exact pilot seating position, the installation placed the pilot's elbow at approximately a right angle. This places the elbow close to the body with his forearm on the arm-rest. This installation was dictated by cockpit constraints but is in close agreement with the recommendations of Reference 21.

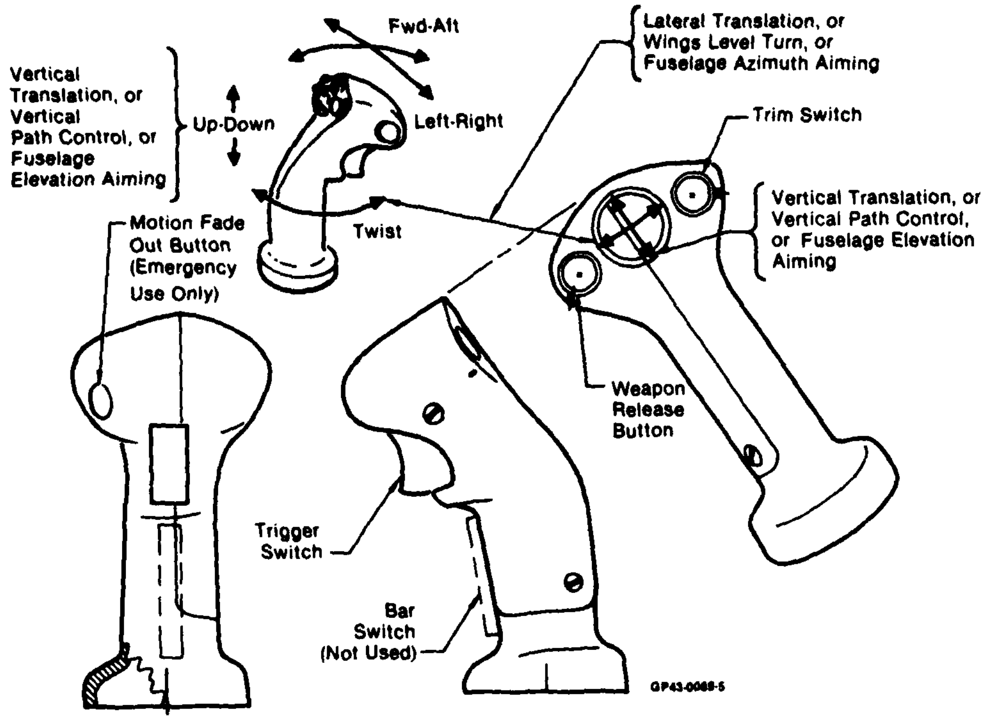

Figure 4. Sidestick Controller With Four Axis Motion

Figure 5. Sidestick Controller and Armrest Installation

The rudder pedals were a McFadden hydraulic loader system which offered great flexibility in configuration selection. Fore and aft neutral position was adjustable for pilot comfort. Rudder pedal position was used as the input to the simulation model. For this investigation the pedal deadband was set to zero, the friction to 1.5 pounds, and damping to 0.797 pounds per inch per second. These values were held constant throughout the simulation. The controller functions varied during the simulation were the breakout, linear gradient, and stop position. Each configuration was hand set and verified by the simulator operators prior to each run.

The throttle used during the simulation was similar to the one used on the AFTI/F-16. The throttle moves in a linear track parallel to the aircraft waterline. The grip extends horizontally from the track. The installation is shown in Figure 6. The unit contains an additional control feature which allows it to be twisted about the horizontal axis as shown in Figure 7. This implementation corresponds well to the responses generated by the uncoupled modes, particularly fuselage elevation aiming and vertical path control. Due to the concentration on lateral modes and some mechanization problems, only limited evaluations of its use during approach and landing were conducted.

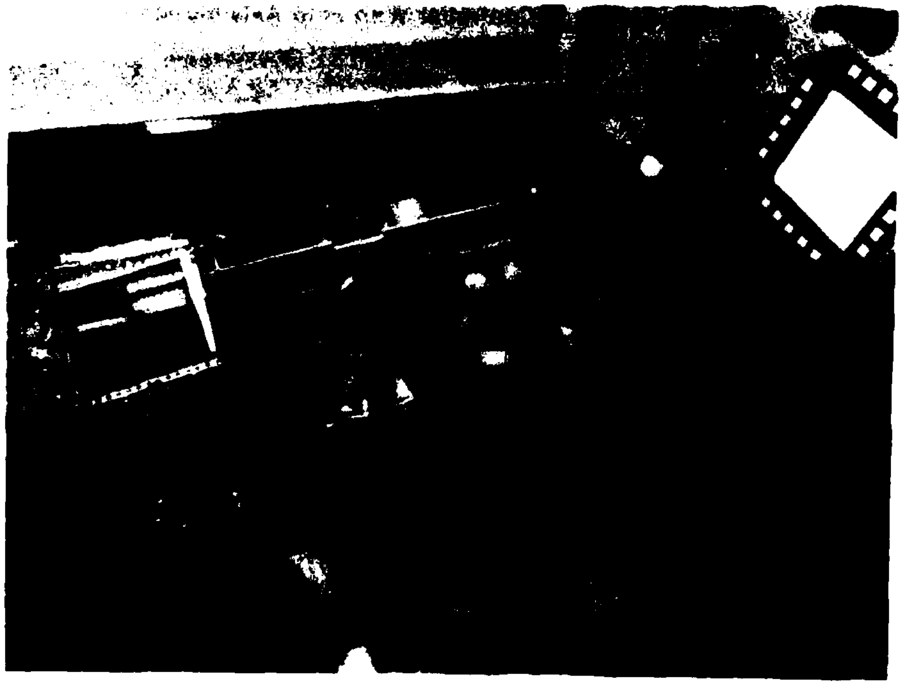

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Figure 6. Throttle Grip Installation

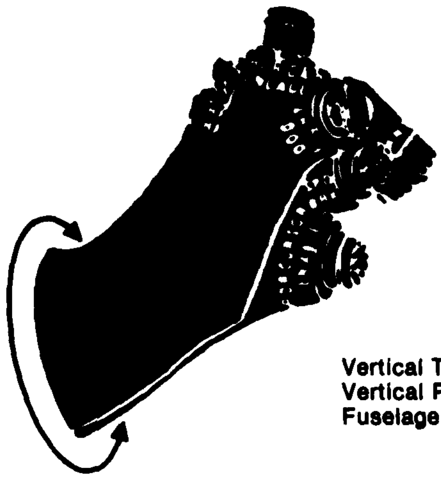


Figure 7. Twist Grip Throttle

A thumbwheel controller mounted on a suitable grip and operated by the pilot's left hand was constructed. The installation of this controller is shown in Figure 8. Use of the controller required that the throttle throw be reduced to approximately one inch. This did not cause serious problems due to task and dynamics selection which minimized or eliminated any change in throttle position. Such an installation is obviously not suitable for actual aircraft use. This controller was used to gather pilot reaction to an unconventional controller which was not part of the primary controller (i.e., sidestick). The thumbwheel was spring loaded to center and could be rotated approximately 90° each side of neutral. Unfortunately, a tight schedule forced testing with the controller to begin soon after its fabrication by personnel at WPAFB and prior to a detailed calibration check. Due to the failure of the return spring during testing, it was not possible to conduct a post-test calibration to determine the exact force-deflection characteristics. Best estimates place the maximum input force at 5 pounds with a nearly linear force to rotation gradient. The thumbwheel was 1 inch in diameter. Comments on controller configurations will be based on estimated degrees of rotation to reach full command in the case of maneuver gradient and deadband examinations.

Figure 8. Thumbwheel Controller Installation

4. COCKPIT DISPLAYS - Pilot cockpit displays used in previous simulations and specific recommendations for display requirements to effectively implement uncoupled aircraft motion can be found in the literature review and mission effectiveness sections of Volume 1. However, computational and time constraints forced the use of simplified display formats for this simulation. A standard set of fighter aircraft instruments was included on the cockpit panel. In addition, a Head Up Display (HUD) was projected on the simulation projection screen. The format of the HUD was a function of task and will be discussed in each task description. Pilot comments indicate that the simplified formats did not detract from the fidelity of the simulation.

5. AIRCRAFT MODEL DESCRIPTION - The generic aircraft program used for this simulation was developed by McDonnell Aircraft Company (MCAIR). The program is designed to allow simulation of handling qualities dynamics of an actual or hypothetical aircraft. This program has been used at MCAIR to evaluate aircraft handling qualities. The primary advantages of the program are 1) the ability for the user to quickly and easily implement configuration changes and 2) the speed of the computations.

The simulation uses transfer functions to specify body position relative to the velocity vector. The resultant accelerations produce changes in the velocity vector orientation. Gravity terms are included when calculating the accelerations. The major simplification used for this program was that the air-

craft rolled around the velocity vector. This is in line with current control system design practices and allowed the pilots to "fly" the airplane without using the rudder pedals to coordinate rolls.

The characteristics necessary to specify the dynamics consist of frequencies, dampings, time constants, and steady state controller-response gains. For this simulation, the tasks were selected so as to minimize speed variations. By doing so it was possible to hold the aircraft dynamics constant, thereby simplifying the model definition.

For the conventional response dynamics it is necessary to construct angle of attack (α_{CR}) and its rate ($\dot{\alpha}_{CR}$) as well as sideslip angle (β_{CR}) and rate ($\dot{\beta}_{CR}$). Additional transfer functions are used to define aircraft roll rate about the velocity vector and aircraft thrust to weight (T/W) as a function of current throttle setting. Block diagrams indicating the form of dynamics used for each conventional response are shown in Figures 9 through 12.

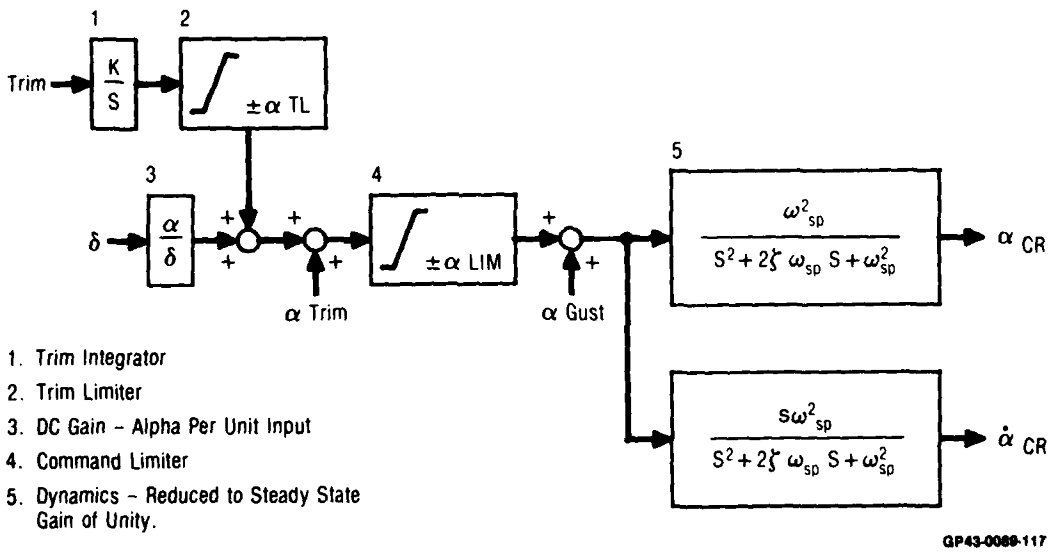
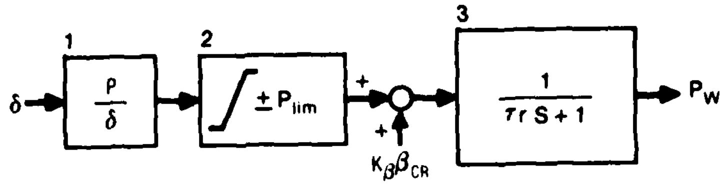


Figure 9. Transfer Function Definition
Longitudinal Axis (Conventional)



1. DC Gain - Roll Rate Per Unit Input
2. Command Limiter
3. Dynamics - Steady State Gain of Unity

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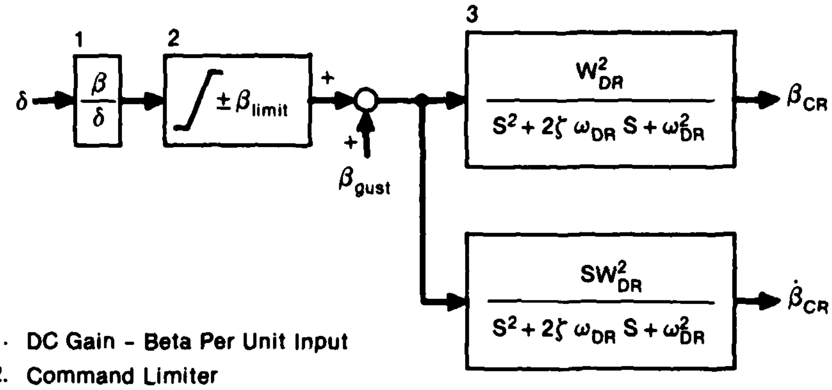
Figure 10. Transfer Function Definition
Roll Axis (Conventional)
(About the Velocity Vector)



1. DC Gain - Beta Per Unit Input
2. Command Limiter
3. Dynamics - Reduced to Steady State Gain of Unity

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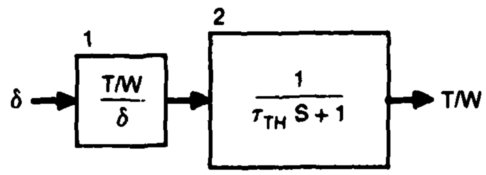
Figure 11. Transfer Function Definition
Directional Axis (Conventional)

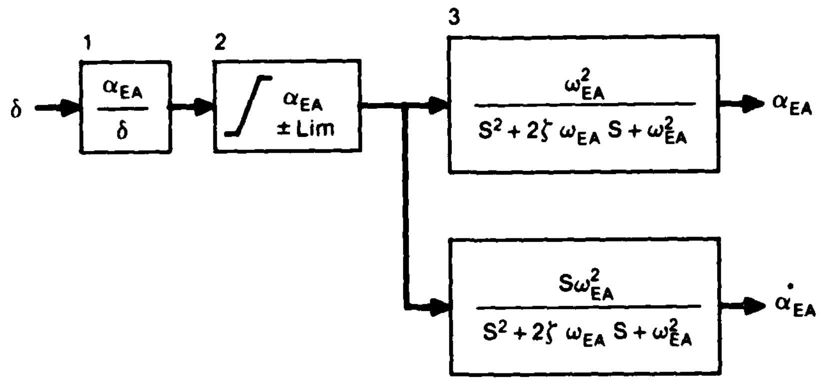


1. DC Gain - Thrust to Weight Per Unit Input
2. Dynamics - Reduced to Steady State Gain of Unity

GP43-0089-120

Figure 12. Transfer Function Definition
Thrust

The uncoupled modes are easily added by considering their primary effect on the aircraft. For the aiming modes, the primary variables are the change in fuselage angle of attack and sideslip (α_{EA} and β_{AA}) and the corresponding rates ($\dot{\alpha}_{EA}$ and $\dot{\beta}_{AA}$). These modes do not effect the velocity vector orientation and therefore no forces due to aiming commands are modeled. The result is a change in fuselage orientation with no change in velocity vector orientation. Block diagrams for these modes are shown in Figures 13 and 14. The second order response shown was determined to be the most appropriate form of the response.



1. DC Gain - Fuselage Rotation Angle Per Unit Input
2. Command Limiter
3. Dynamics - Reduced to Steady State Gain of Unity

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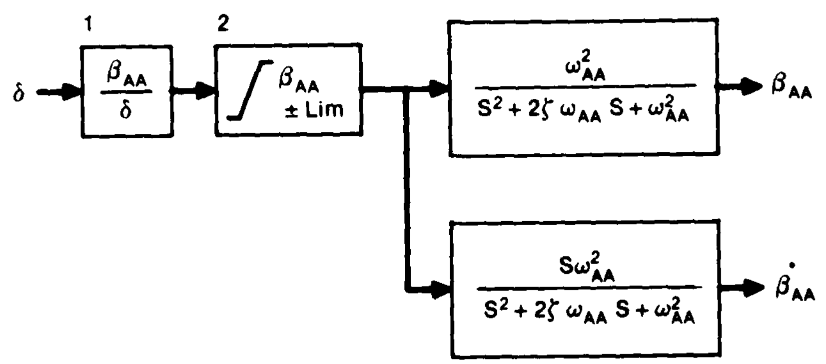
Figure 13. Transfer Function Definition
Fuselage Elevation Aiming

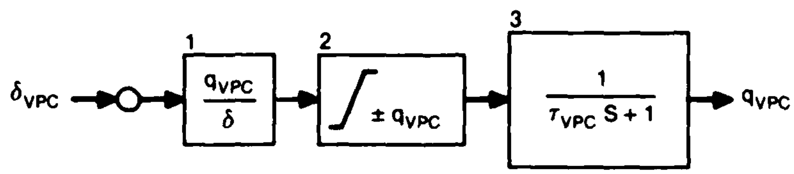


1. DC Gain - Fuselage Rotation Angle Per Unit Input
2. Command Limiter
3. Dynamics - Reduced to Steady State Gain of Unity

GP43-0088-122

Figure 14. Transfer Function Definition
Fuselage Azimuth Aiming

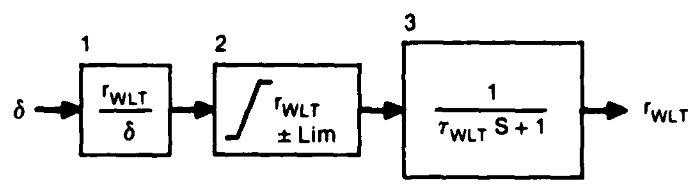
The vertical path control and wings level turn mode provide changes in velocity vector orientation while holding the fuselage-velocity vector relationship constant. To model these responses, transfer functions were used to define a velocity vector pitch rate (q_{VPC}) and yaw rate (r_{WLT}). Using the kinematic relationship of angular rate and centripital acceleration, the corresponding accelerations were calculated and applied to the velocity vector, producing the desired response. For these modes, a first order response was felt to best represent this form of flight path control. Block diagrams for these responses are shown in Figures 15 and 16.



1. DC Gain - Pitch Rate Per Unit Input
2. Command Limiter
3. Dynamics - Steady State Gain of 1

GP43-0089-123

Figure 15. Transfer Function Definition
Vertical Path Control (VPC)

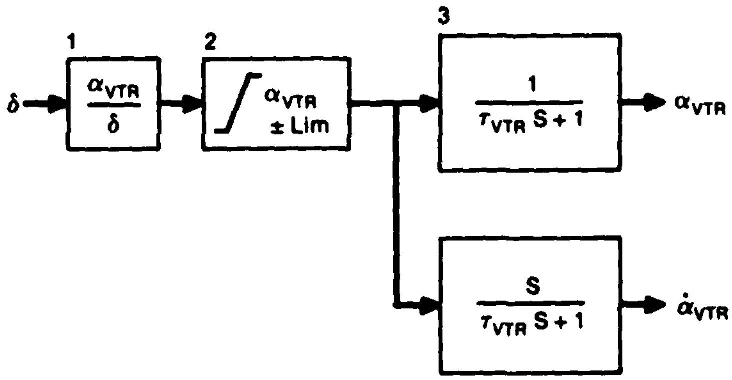


1. DC Gain - Yaw Rate Per Unit Input
2. Command Limiter
3. Dynamics - Steady State Gain of One

GP43-0089-124

Figure 16. Transfer Function Definition
Wings Level Turn

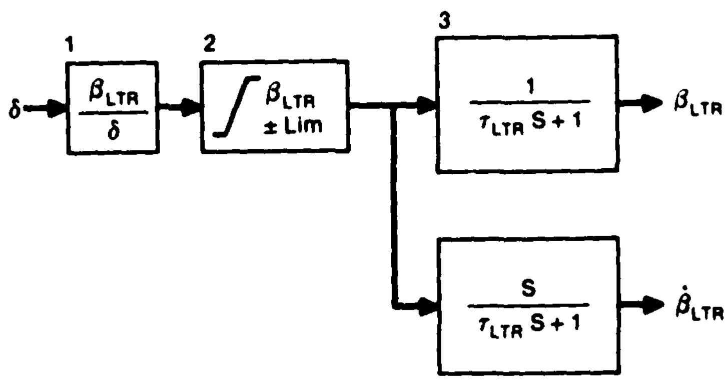
The vertical and lateral translation modes are unique in that they specify a change in velocity vector orientation and an offsetting change in the fuselage-velocity vector relationship such that fuselage attitude remains constant. This is accomplished by calculating the change in angle (α_{VTR} and β_{LTR}) and rate ($\dot{\alpha}_{VTR}$ and $\dot{\beta}_{LTR}$) of the fuselage-velocity vector relationship. Using the kinematic relationships, accelerations are calculated which are proportional to the angular rates but opposite in sense. These accelerations are then applied to the velocity vector to produce the desired change in orientation. These modes are also modeled by a first order response. The block diagrams are shown in Figures 17 and 18.



1. DC Gain - Effective Alpha Per Unit Input
2. Command Limiter
3. Dynamics - Steady State Gain of One

GP43-0000-125

Figure 17. Transfer Function Definition
Vertical Translation



1. DC Gain - Effective Beta Per Unit Input
2. Command Limiter
3. Dynamics - Steady State Gain of One

GP43-0000-126

Figure 18. Transfer Function Definition
Lateral Translation

As mechanized, the uncoupled modes result in "pure" responses with no contamination to the other control axes. No drag due to uncoupled mode usage was added during this simulation. It was felt that this would unnecessarily complicate the evaluation of the controller characteristics. In actual use the drag would produce a significant impact on aircraft performance. Any study aimed at a specific application of uncoupled motion must consider the impact of drag on mission effectiveness for the configuration being examined.

The model contains some options for specialized configurations, tasks, and control system implementation. These options will be discussed in the sections which deal with their area of applicability. In addition, numerical values for the aircraft dynamics used will be given in the specification of each task used in the simulation.

6. <u>TURBULENCE AND WIND MODELS</u> - For some of the tasks it was desirable to use an atmospheric disturbance model which included turbulence and wind effects. It is important that the reader remember the purpose of the simulation. The simulation was not to evaluate turbulence suppression or the exact effects of wind shear on the aircraft. The effects used here were aimed at providing disturbances to the model to emphasize pilot controller usage. This is not meant to detract from the model, but rather to explain some of the simplification used in the disturbance implementation.

The turbulence model used was proposed by Systems Technology, Inc. (STI) and had been used successfully in previous simulations. For this application, the model was modified to introduce perturbations in aircraft angle of attack and sideslip commands. A crossfeed was implemented such that sideslip gusts produced a roll rate command in the model roll axis. The angle of attack and sideslip gusts (α_g and β_g) were calculated using the transfer functions:

$$\frac{\alpha_g}{N_\alpha} = \frac{(\sigma w_g/U)(3R_\alpha)^{1/2}}{S + 1.5\,R_\alpha} \qquad (1)$$

$$\frac{\beta_g}{N_\beta} = \frac{(\sigma v_g/U)(3R_\beta)^{1/2}}{S + 1.5\,R_\beta} \qquad (2)$$

The terms N_α and N_β are independent Gaussian noise sources. They can be calculated as follows:

$$N_\alpha = (1/T)^{1/2}[2.865\nu_1 - 5.509\nu_1^3 + 48.23\nu_1^5] \qquad (3)$$

$$N_\beta = (1/T)^{1/2}[2.865\nu_2 - 5.509\nu_2^3 + 48.23\nu_2^5] \qquad (4)$$

The variables μ_1 and μ_2 in equations (3) and (4) are independent, uniformly distributed random numbers between ± 0.5 and T is the sample period of the digital computer. The purpose of the $(1/T)^{1/2}$ term in equations (3) and (4) is to force the power spectral density functions of N_α and N_β to have the same root mean square (rms) value as white noise.

The terms R_α and R_β in equations (1) and (2) ensure the proper power and frequency content for the model dependent on aircraft velocity and altitude. These values were defined as:

$R_\alpha = R_\beta$ = true Velocity/Atmospheric Scale Length

The atmospheric scale length is as defined in MIL-F-8785C as a function of altitude. A value of 1750 was used in this simulation.

The U in equations (1) and (2) is defined to be the aircraft true velocity. The terms σ_{wg} and σ_{vg} are in units of feet per second. These terms are used to define the intensity of the turbulence to be modeled. Numerical values used will be indicated where applicable in the task discussions.

A wind model was developed which included the capability to specify a wind shear. The model was implemented by adding wind velocity components to the aircraft inertial velocities. As such, the model does not provide an accurate representation of the effects of wind shear. It did, however, provide a disturbance to the aircraft ground track which the pilot was required to account for. Specific details of magnitudes and direction will be discussed in the approach and landing task description. This was the only task in which the wind model was utilized.

7. PILOT SELECTION - Due to the long duration of the simulation program it was not possible to select three or four pilots to participate in the entire evaluation process. It is felt that this number of pilots would have been the preferred number in terms of maintaining proficiency, minimizing retesting and training, and maintaining continuity across the test matrix.

A total of 12 pilots from the 4950th Test Wing stationed at Wright-Patterson AFB participated in the simulation. All of these pilots were graduates of the USAF or USN Test Pilot School. Experience ranged from helicopter to fighters and heavy transports. These pilots had previous test experience and were on current flying status. Two additional pilots were from the Flight Dynamics Laboratory Test and Evaluation Group. These pilots had extensive operational and simulation experience. The last pilot was from the Flight Dynamics Laboratory, Control Dynamics Branch. This pilot had a background of recent operational experience and was currently assigned to the group responsible for flying qualities requirements. A summary of available pilot experience is included in Appendix D.

8. PILOT FAMILIARIZATION - Prior to the simulation, a ten day period was designated for pilot briefing and simulator familiarization. Eight of the potential pilots were given a briefing describing the purpose of the simulation, controllers to be examined and possible tasks to be used. These pilots were also given the opportunity to fly the simulation. Three types of tasks were identified in the briefing, air-to-ground weapon delivery, STOL fighter approach and landing, and air-to-air tracking. For the simulator familiarization, primary emphasis was given to the air-to-ground tasks and to the use of the sidestick controller for conventional response control. During this period, conventional response dynamics were fine tuned to a configuration acceptable to the majority of pilots. In general, the pilots readily adapted to sidestick despite some initial sensitivity problems. No problems were noted with controller or armrest positioning.

9. THE PILOT EVALUATION METHODS - Using specific tasks, defined in Section 11, the pilots were asked to evaluate a specific controller for a specific uncoupled mode. The pilot evaluation consisted of three items: the pilot rating, the pilot comments and the pilot remarks on a post program questionnaire.

a. Pilot Ratings - Pilot ratings give a numerical score to the overall configuration in the task in which it was flown. This rating was in accordance with the Cooper-Harper Rating Scale. The rating process leads through a network of decision logic which results in a numerical score of from one (1) to ten (10). The score is not relative to any other aircraft, but rather the decision logic of the rating scale leads to an absolute number. In order to maximize the rating consistency among pilots, there must be a clear understanding of the context and definition of the primary decision making terms. The pilot's decision process is simplified by arranging a sequential series of selections between two alternatives that lead to the proper category selection.

This structure is shown in Figure 19, where a flow chart is presented to enable tracing the series of choices which the pilot makes in arriving at the final rating. As a rule, the first decision may be fairly obvious. Is the configuration controllable or uncontrollable?

If the airplane is uncontrollable in the task, it is rated 10. If it is controllable, the second decision examines whether it is acceptable or unacceptable. If unacceptable, the ratings 7, 8 and 9 are to be considered (rating 10 has been excluded by the "controllable" answer to the first decision). If it is acceptable, the third decision must examine whether it is satisfactory or unsatisfactory. If unsatisfactory, the ratings 4, 5 and 6 are to be considered; if satisfactory, the ratings 1, 2 and 3 are to be considered.

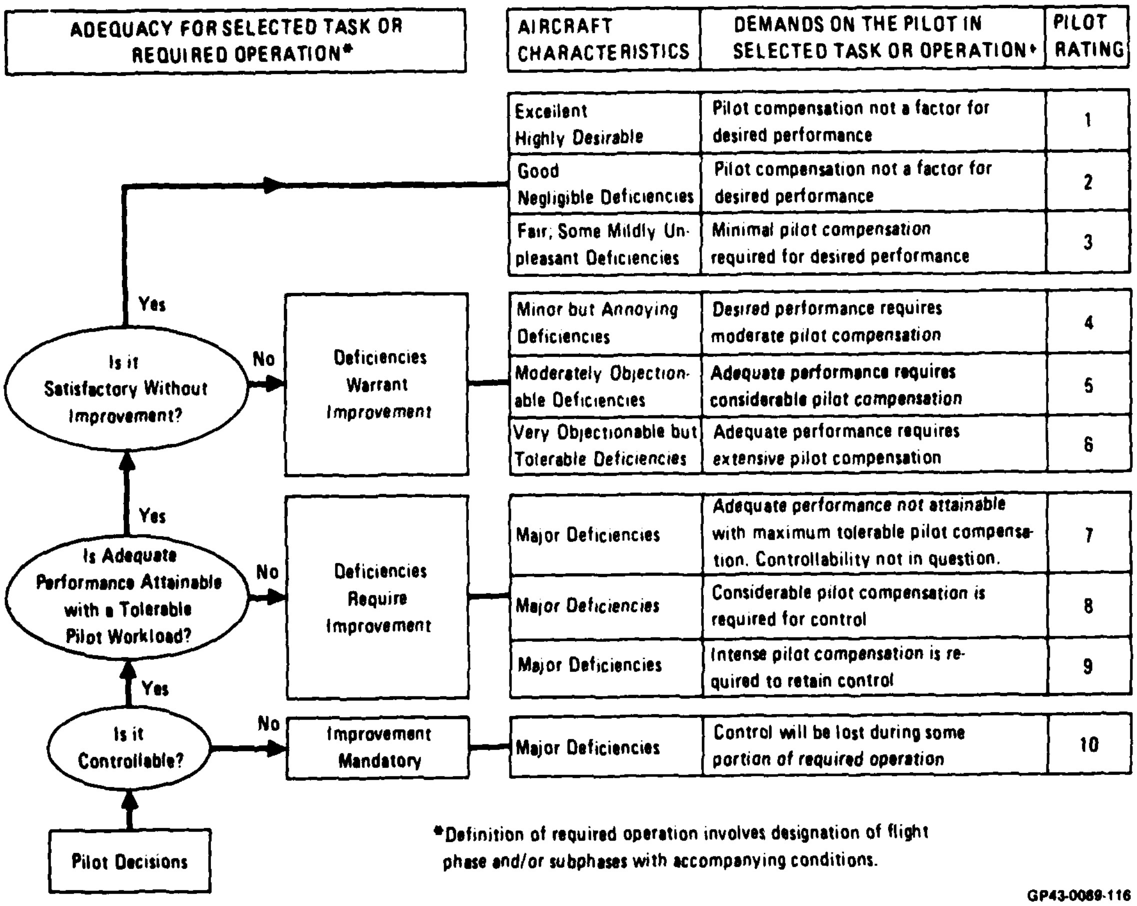


Figure 19. Cooper-Harper Rating Scale

The basic categories must be described in carefully selected terms. Let us examine what is meant by controllable. To control is to exercise direction of, or to command. Control also means to regulate. The determinations as to whether the airplane is controllable or not must be made within the framework of the defined task or intended use. An example of the considerations of this decision would be the evaluation of fighter handling qualities during which the evaluation pilot encounters a configuration over which he can maintain control only with his complete and undivided attention. The configuration is "controllable" in the sense that the pilot can maintain control by restricting the tasks and maneuvers which he is called upon to perform, and by giving the configuration his undivided attention. However, for him to answer "Yes, it is controllable in the task", he must be able to retain control in the mission tasks with whatever effort and attention are available from the totality of his task duties.

The dictionary shows acceptable to mean that a thing offered is received with a consenting mind, unacceptable to mean that it is refused or rejected. Acceptable means that the mission can be accomplished; it means that the evaluation pilot would agree to buy it for the task. "Acceptable" in the rating scale does not say how good it is for the mission, but it does say it is good enough. With these characteristics, the task can be accomplished. It may be accomplished with considerable expenditure of effort and concentration on the part of the pilot, but the levels of effort and concentration required in order to achieve this acceptable performance are feasible in the intended use. By the same token, unacceptable does not necessarily mean that the task cannot be accomplished; it does mean that the effort, concentration, and workload necessary to accomplish the task are of such a magnitude that the evaluation pilot rejects that airplane for the mission.

Consider now a definition of satisfactory. The dictionary defines this as adequate for the purpose, of a kind to meet all requirements or expectations. A pilot's definition of satisfactory might be that it is not necessarily perfect or even good, but it is good enough that he would not ask that it be fixed. It meets a standard, it has sufficient goodness; it is of a kind to meet all requirements of a task. Unsatisfactory, though acceptable, implies that the objectionable characteristics should be improved if possible, that it is defective or deficient in a limited sense, that there is insufficient goodness, that it is reluctantly acceptable.

Thus the quality is either:

		Pilot Rating
Buy	(a) completely acceptable (satisfactory) and therefore of the best category with no improvement recommended, or	1 - 3
	(b) reluctantly acceptable (unsatisfactory) and of the next best category with certain improvements recommended, or	4 - 6
Won't Buy	(c) unacceptable, not suitable for the mission but still controllable, and in the third category, or	7 - 9
Won't Fly	(d) unacceptable for the mission and uncontrollable, and of the poorest quality.	10

When reviewing the complete rating scale (Figure 19), it is seen that it includes further subdivisions of quality within each of the four categories. These subdivisions incorporate descriptions to define quality differences separating each numerical

rating. It is emphasized, however that these descriptions supplement the series decisions which lead the evaluation pilot to the particular category within which the description of the individual ratings are given. That is to say, the pilot should not make his rating decision based upon the individual descriptions alone. These are most meaningful when used in conjunction with the category decisions.

Each new mode and controller combination (e.g., wings level turn with rudder pedals) was flown as needed in each task for familiarization purposes. Data taking runs (scoring and pilot ratings) were repeated as necessary for the pilot to decide on a pilot rating. To preclude any crossfeed between pilots affecting the individual ratings, pilots were discouraged from monitoring other pilot's runs, especially when they are next scheduled to fly the simulator.

A firm commitment of a pilot rating is requested. Half ratings or ratings indicating a range of values were discouraged and were not accepted. The pilots were encouraged to use the Cooper-Harper scale and rating decision process explained to provide the rating.

Pilots were directed not to attempt to compensate for simulator limitations in their ratings. These problem areas were addressed separately.

b. Pilot Comments - The pilot comments are a description of the configuration's major characteristics in the pilot's own words and in "pilot language". Each pilot was told to report what he saw and felt, and describe his difficulties in carrying out the specific task he was attempting. These comments are of extreme importance in assisting the engineer in identifying particular system characteristics that influenced the pilot rating. These comments were recorded on tape following the configuration rating runs. The comments were guided by the comment sheet shown in Figure 20. They were as lengthy or as brief as the pilot felt necessary to relay his impressions of each particular configuration. Comments relative to the simulation in general were held until the post-simulation debriefing and questionnaire. This allowed a more efficient use of the in-the-cockpit simulation time. The abridged pilot comments are included in Appendix E.

At the end of a series of runs involving a given controller and task a Controller Usefulness Questionnaire was completed. This was to aid in accessing the appropriateness of the controller for a given task. These are shown in Appendix F. Specific characteristics such as breakout and feel gradient were not addressed in this questionnaire since these effects on pilot opinion will have been addressed previously.

1. Pilot Rating Using the Cooper-Harper Rating Scale

2. Control Feel Characteristics

   A. Forces

   B. Displacements

   C. Harmony

3. Control Sensitivity

4. Control Authority

5. Airplane Response to Pilot Inputs

   A. Roll Control

   B. Directional Control

   C. Pitch Control

   D. Uncoupled Mode Control

6. Effects of Turbulence on Airplane Response

7. Special Piloting Technique Required

8. Summary Comments

   A. Primary Reason for Rating

   B. What Effect Did Any Simulation Limitations Have on Your Ratings?

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Figure 20. Pilot Comment Card

c. Post-Simulation Questionnaire - The purpose of this questionnaire was to provide the pilots the opportunity to express their opinion of the simulation program in general. The questionnaire was to be completed at the end of their participation in the simulation program. Significant comments and ideas could therefore be incorporated in future efforts. These are shown in Appendix G.

10. SIMULATION TASKS, DISPLAYS, AND PERFORMANCE MEASURES - Three basic tasks were used in the evaluation of the various controller-uncoupled mode configurations:

1. Air-to-Ground Weapon Delivery
2. STOL Fighter Approach and Landing
3. Air-to-Air Tracking

These tasks were selected because they represent the broadest range of application for uncoupled motion usage.

Where possible, every effort was made to keep the tasks as realistic and operationally oriented as possible. Each task had been outlined prior to the simulation. During pilot familiarization sessions, comments and suggestions on task improvements were solicited and incorporated where possible. Head Up display formats were changed as necessary to facilitate effective mode usage.

a. <u>Air-To-Ground Weapon Delivery</u> - Two air-to-ground tasks had been identified for use with the wings level turn mode, air-to-ground dive bombing and strafing. For the fuselage azimuth aiming mode, air-to-ground strafing was selected as the evaluation task. Both tasks were initiated from a pop-up maneuver.

For both tasks, a fixed, non-depressed aiming cross displayed on the HUD was used as an aimpoint. Additional information available to the pilot on the HUD included:

- o Digital readouts of altitude, airspeed, and pitch attitude
- o Aircraft velocity vector
- o Horizon line

The HUD display is shown in Figure 21. The nondepressed, fixed sight is not indicative of operational display types on modern fighter aircraft. However, it did serve two purposes. The fixed sight removed sight dynamics as an experimental variable. The zero depression angle eliminate pipper pendulum effects during roll corrections. Elimination of pendulum effects had been sighted in previous efforts (References 44 and 52) as a major benefit of uncoupled aircraft motion. Modern control and sight dynamics can be used to eliminate pendulum effects without the added complexity of uncoupled control modes. The same display was used for the wings level turn and azimuth pointing modes.

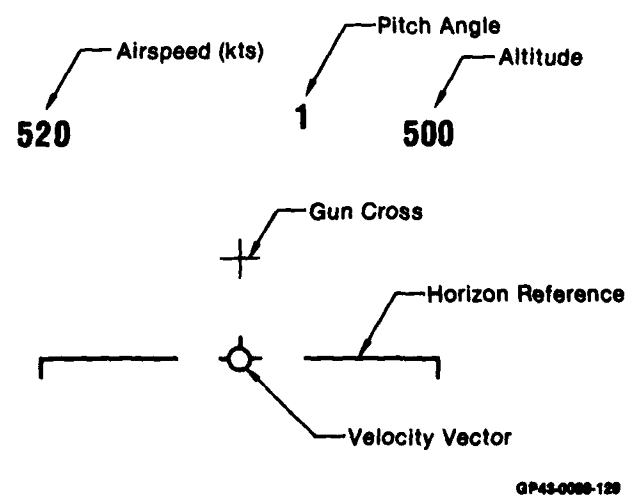

Figure 21. Air-to-Ground Head Up Display (HUD)

Originally, it was planned to score each run for pipper error at the time of weapon release. The targets were chosen to be features on the terrain board. Due to hysterisis problems of camera positioning it was not possible to construct an error measure. Consideration was given to using a HUD displayed target symbol such as used in Reference 44, with the terrain board providing a background image. Calibration and display problems resulted in the HUD displayed target "wandering" around the terrain board image. This effect was determined to be too distracting to the pilots. As a result, the only scoring used were the previously detailed pilot ratings and comments. Time history data of aircraft states and pilot inputs was stored on magnetic tape for future review.

The discussion of task details is best done by considering each uncoupled mode examined. In all cases, an observer watched each run and monitored pilot methods to ensure task commonality.

(1) Wings Level Turn - The wings level turn evaluations began with the use of two tasks: dive bombing and strafing. The dive bombing task was initiated at 500 KCAS, 500 feet above ground level (AGL), six miles from the target. At 3 to 4 miles from the target, the pilot initiated a 4g pullup to a 30° climb until reaching 2500 feet AGL. The pilot then executed a 180° roll and pulled 2 to 4 g's and rolled out in a 20° dive on the target. Release conditions were 2000 feet, AGL at 500 KCAS. After release the pilot executed a high g turn and exited the target area. The target was the lefthand corner of the runway threshold. Figure 22 illustrates the dive bombing task.

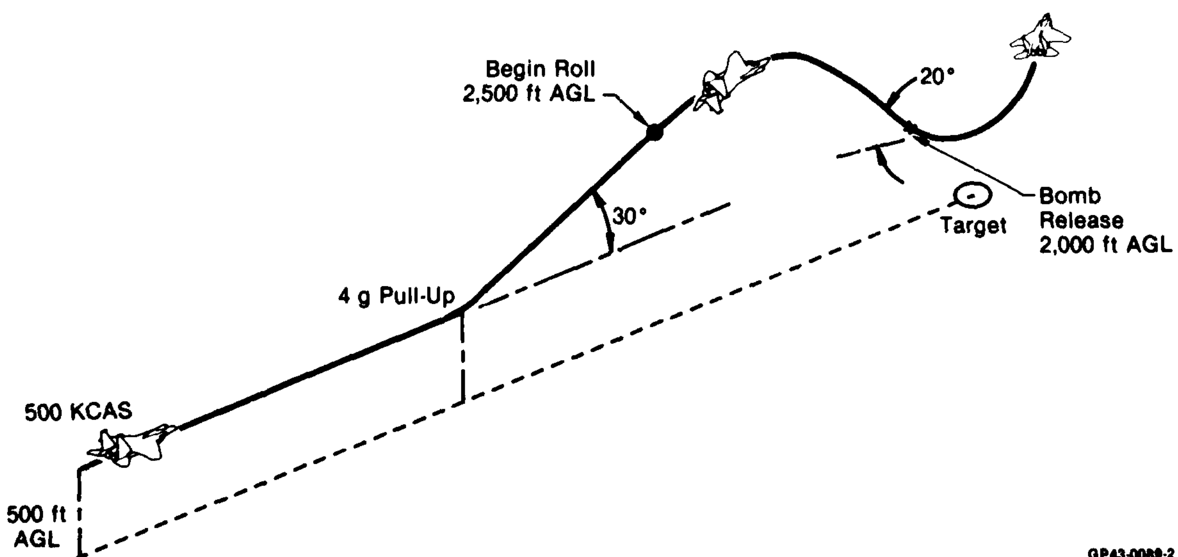

Figure 22. Air-to-Ground Bombing Pop-Up Maneuver

The air-to-ground strafing task was initiated at the same conditions as the bombing task. Three to four miles from the target the pilot initiated a 4g pullup to a 20° climb attitude. At 1500 feet AGL the pilot executed an unloaded 180° roll and pulled 2 to 4 g's. The pilot then rolled out in a 10° dive at 500 KCAS. Tracking began by stabilizing on one corner of the runway threshold, squeezing the trigger, translate using wings level turn to the opposite corner and again squeezing the trigger. If time permitted the pilot would also take a shot at the runway centerline. Recovery was initiated at approximately 1000 feet AGL. The distance between outside targets was approximately 275 feet. This profile is illustrated in Figure 23.

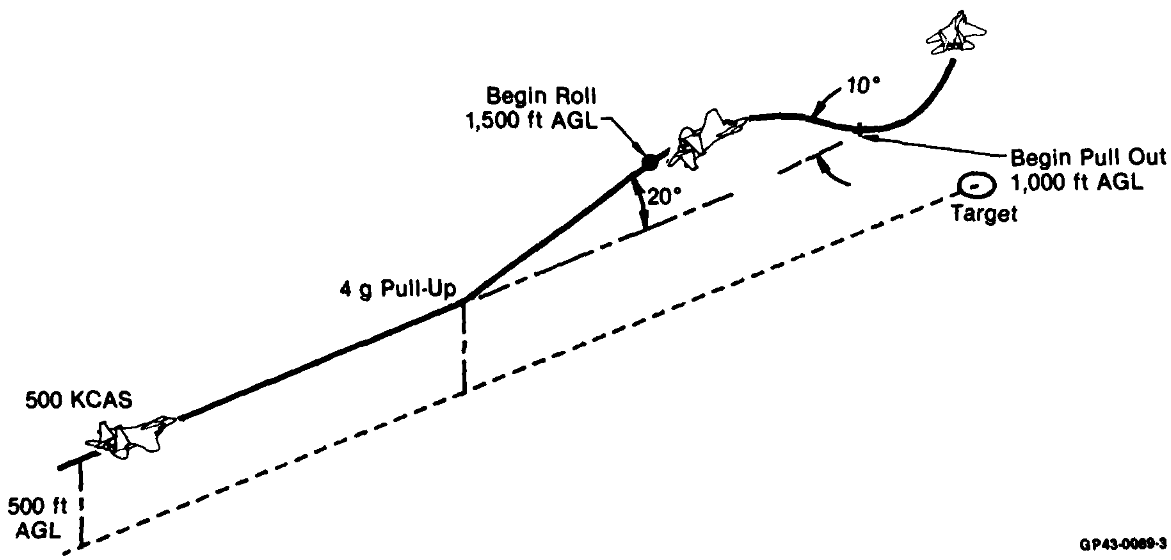

Figure 23. Air-to-Ground Strafing Pop-Up Maneuver

In an actual operational environment, the target would normally be offset approximately 40° from the initial pullup point. This would allow the pilot to keep the target area in sight at all times. Due to the limited forward field of view, the simulation pilots lost ground reference during the climb phase. To facilitate target acquisition, the target was always within 2000 feet of the initial run in line. This allowed the pilots to execute a 180° roll at the top of the pullup with a high degree of confidence that they would roll out close to the target. Prior to each run, the pilot was informed of the target offset distance and direction. The pilots were encouraged to always roll towards the target to prevent them from establishing a consistent pattern of always rolling in one direction.

Both the bombing and strafing tasks were used early in the simulation. Pilot comments indicated that while the tasks were of about equal difficulty, the dive bombing task really did not allow sufficient time to evaluate the controller characteristics. For this reason the dive-bombing task was discarded. Another interesting comment indicated that the pilots felt the strafing task was nearly impossible to do with the conventional airplane within the altitude limits. The ability to move the piper directly to the next target using only one controller greatly simplified the task and encouraged the pilots to use the mode.

(2) Fuselage Azimuth Aiming - The fuselage azimuth aiming mode, also known as azimuth pointing, allowed the pilot to point the nose independent of the aircraft flight path. The primary task was an air-to-ground strafing profile using multiple targets. This task was initiated at the same conditions and used the same pop-up maneuver (Figure 23) as the wings level turn air-to-ground task outlined earlier. However, for this task three distinct targets were used. These targets consisted of three buildings approximately 50 feet wide by 30 feet tall spaced 500 feet apart perpendicular to the run-in line.

The typical attack began with the pilot rolling out lined up on the center building and squeezing the trigger. The pilot would then move the gun cross to the left target, stabilize the cross and squeeze the trigger. The pilot repeated this process with the right and center targets, in that order, before initiating the pull-out. An alternate attack profile using the right building as the second target was used. The target sequence was always center, side, opposite side and back to center before pullout. As in the wings level turn evaluations, the run-in line was varied such that the center target was offset up to 2000 feet either side of the line. Prior to each run, the pilots were informed of center target offset magnitude and direction and the desired target sequencing. This procedure was designed to prevent pilot inputs from becoming too mechanical.

The size of the targets was driven by the requirement that the pilot be able to identify them at the beginning of the dive. Due to the contrast and clarity of the display, the chosen targets were near the minimum acceptable size. In the typical mission profile, the pilot rolled in on the first target at 2000 feet AGL at a slant range of 11,500 feet. The pullup was initiated upon passing through 1000 feet AGL at a slant range of 5700 feet. Computing the apparent target widths in milliradrans (mils) the target width was 4.3 mils at roll-in and 8.6 mils as the pilot lined up on the last target. Total time between roll-in on first target and initiation of pull-up was approximately 7 seconds. Based on a typical profile, a maximum 7.5 degrees of authority was required for the third target. Ten degrees of authority was available.

This task was felt to offer an excellent opportunity to evaluate controller characteristics. Rapid, accurate positioning was required. Additionally, operation about and through the neutral controller position allowed examination of breakout and deadband characteristics. The only major drawback was the relatively short duration and high activity required. Attempts by and comments from the pilots indicated that this task could not be accomplished using the aircraft conventional response capabilities.

b. STOL Fighter Approach and Landing - The landing task is another area where the use of uncoupled aircraft control may greatly increase precision and safety while reducing pilot workload. The increase in precision has significant implications for carrier based aircraft and aircraft operating from short fields due to runway denial or the use of unimproved airstrips.

The landings were conducted using the terrain board projection system. The HUD was superimposed on this display as done in the air-to-ground evaluations. HUD symbology included the information on the air to ground display plus an angle of attack indicator and instrument landing system (ILS) crosshairs. The HUD display is illustrated in Figure 24. The ILS crosshairs were driven with raw data expressing deviation from the desired approach path. Due to the use of raw data and the poor resolution of the crosshairs, all landings were made in visual meterological conditions. The angle of attack indicator provided a reference point for the trim angle of attack and was scaled to indicate $\pm 1°$ deviations from this condition.

The task selected was to touchdown on a clearly defined 50 feet wide by 200 feet long segment of the runway in the presence of 3 feet per second rms vertical and horizontal turbulence and a 15 knot, 90° wind shear. The approach was initiated at one mile on a 4 degree glide slope. The approach speed was 115 knots. The task started with a 15 knot headwind until 330 feet AGL were upon the wind vector was linearly rotated with altitude to a 90° crosswind at 5 feet AGL.

In accomplishing this task, the wings level turn mode was used to establish and maintain the desired crab angle in the presence of the wind shear. This technique is much the same as that used with a conventional aircraft, however, wings level turn provided a direct control of the aircraft velocity vector lateral placement. Using this mode the pilots were allowed to touchdown in a crab. It should be mentioned that at the airspeed and crosswinds used, this technique resulted in approximately a 7 degree crab angle at touchdown. Pilot comments indicated this angle was near the maximum they would feel comfortable with in operational use.

The other modes evaluated in this task included lateral translation and fuselage azimuth aiming. The pilots were instructed to eliminate the majority of crab angle prior to touchdown when using these modes. The lateral translation mode

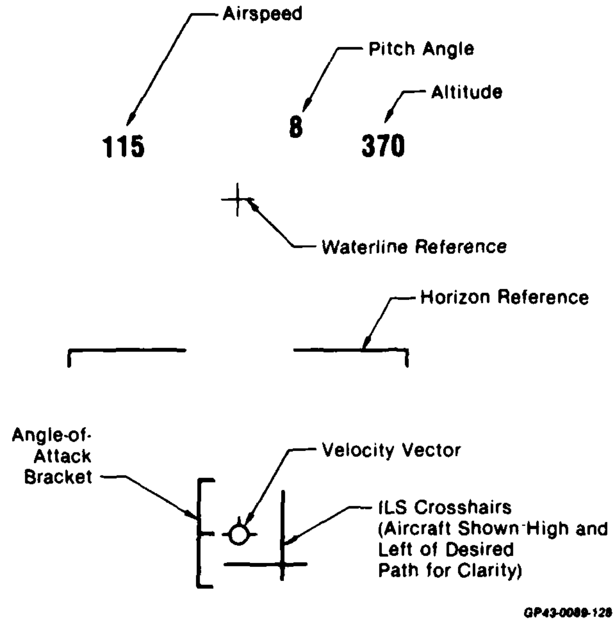

Figure 24. Approach and Landing Head Up Display

allowed the pilot to cancel any crosswind effects while maintaining the aircraft heading parallel to the runway. When using the azimuth aiming mode, the pilot would establish the proper ground track using the conventional aircraft responses. The azimuth aiming mode was then used to eliminate the crab angle prior to touchdown. Pilot technique varied somewhat in that some pilots would wait to the last minute to use the mode while others would use the modes continuously during the approach.

A limited evaluation of controllers for the vertical translation mode was conducted during this phase. Two pilots participated in this evaluation. One pilot used the mode as a means of alleviating sink rate immediately prior to touchdown. The other pilot, during this phase, would use the conventional aircraft response to kill off some sink rate and then use the vertical translation as necessary to control touchdown point placement. In all other evaluations, the pilots made unflared landings.

The mode dynamics used during these evaluations will be described in detail, along with the controller characteristics examined, in the next section. Additionally, during the later portions of the landing evaluations, motion system oscillation independent of the aircraft were injected to examine motion-controller coupling.

c. <u>Air-To-Air Tracking</u> - The literature survey had indicated several possible applications of uncoupled motion control in air-to-air combat. These included the use of wings level turn as a fine tuning method, the use of azimuth aiming for accurate weapons system aiming, and the use of translation as a defensive maneuver.

Initial plans were to examine the use of the wings level turn and azimuth pointing modes. During a task development session, potential tasks for use with the azimuth pointing mode were examined. It became apparent that there would be some difficulty in defining a continuous tracking task using this mode. Snap shot type firing solutions were easily obtained, however, the pilot indicated that using the mode in continuous tracking of a maneuvering target was like "trying to integrate six equations of motion in your head." These comments are in line with findings from the previous studies which indicated that the best implementation may be as an automatic mode controlled by the fire control system. As a result of these findings, only the wings level turn mode was examined.

To minimize pilot learning effects and provide continuity with the previously obtained data, we had planned to use the same flight conditions, aircraft dynamics, and authorities used in the air-to-ground tasks. It became apparent in task checkout that the pitch axis was too sensitive for very precise air-to-air tracking even though it had been found acceptable in the air-to-ground evaluations. Details of the steps taken to eliminate this problem are explained in the following section on configuration dynamics.

The initial flight conditions were Mach .8 at an altitude of 1000 feet. Each evaluation was structured such that 60 seconds of tracking information was recorded. Because of the large area covered, no terrain board images were used. The pilot display consisted of a 277° sky-earth horizon representation, a projected HUD image as shown in Figure 25, and a computer generated target aircraft. The HUD symbology included digital pitch, airspeed and altitude information. The pilot was also provided with an horizon reference bar and velocity vector. The aiming cross was encircled by a 50 mil diameter reticle which include a range bar on the outside perimeter. The range bar was scaled such that the desired 1500 feet value occurred when the bar terminated at the six o'clock position. The pilots were encouraged to maintain a constant range to target. If the range fell below 1000 feet or beyond 2000 feet the run was aborted and the configuration re-evaluated at a later time.

Air-to-air fine tracking tasks were used exclusively. Two target types were recorded; one involving near constant altitude, moderate amplitude target roll motions and one involving small roll perturbations about a level 2g turn. Target airspeed was held at a constant magnitude.

The target trajectories were prerecorded by flying the simulation model through the desired maneuvers and recording the aircraft angular and linear accelerations. All target perturbations were done by injecting a sum-of-sines roll rate command into the model. Crossfeeds into the pitch axis resulted in a target which maintained near constant altitude. The sum-of-sines used the same form, frequencies, and amplitudes for all cases. These are shown in Table 1. A gain was applied to the sum-of-sines signal to achieve the desired target motion amplitudes.

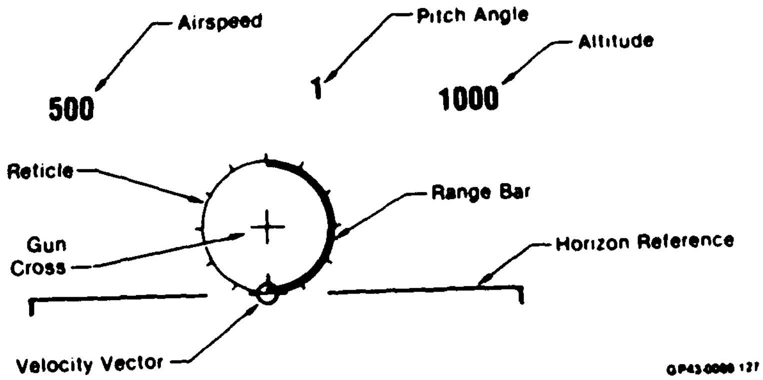

Figure 25. Air-to-Air Head Up Display
Target Not Shown for Clarity

TABLE 1. SUMS OF SINES TARGET DRIVE SIGNALS

From $\Delta p = \sigma_{\Delta p} \sum_{i=1}^{5} A_i \sin(\omega_i t + \phi_i)$

i	A_i	ω_i (rad/sec)	Harmonic Number (Cycles/Run Length)
1	0.9328	0.25	2
2	0.7838	9.63	5
3	0.5825	1.88	15
4	0.3519	4.40	35
5	0.2290	9.42	75

$\sigma_{\Delta 1p}$ = 0.145 for Turning Target
= 0.290 for Level Target

Note ϕ all set to $+\pi/2$ for one target record and $-\pi/2$ for other

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The moderate target bank angle task was devised as a one dimensional tracking task. The sum-of-sines signal was scaled to provide a standard deviation of 26° about a mean bank angle of 0°. This provides a target with a maximum of .5g of acceleration in the horizontal plane. The pilot's task was to track this target using the wings-level turn mode and keeping the bank angle near zero.

For the second task, the target started straight and level. After 4 seconds the target rolled into a constant speed, constant altitude 2 g turn. At that point the sum-of-sines signal was used to generate bank angle perturbations having a 13° deviation from the nominal $\pm 60°$ bank. The pilot's task was to track this target using bank and pitch control. The wings level turn was then used to fine tune the lateral tracking solution.

Two recordings were made of each target type. The phase angles were adjusted such that each recording was a mirror image of the other. In the case of the turning targets one would bank left; the other was a right turn. During the evaluations the pilots did not know which target they would see within each type. The pilots were told if the target was a turning task or a level task prior to each evaluation.

In an attempt to spur pilot motivation each run was scored for accuracy. These scores took the form of total time trigger was pulled and time within 5 and 10 mils of the target with trigger pulled. The pilot was informed of his scores for a particular evaluation after the pilot ratings and comments had been collected. Thus, the scores provided a means of telling the pilot how he was doing without influencing his ratings or comments.

At the beginning of the second week of testing, a hydraulic pump failure forced a decision to carry on in the fixed base mode or wait for the motion drive to be repaired. The decision to halt testing was made after it became apparent that it might not be possible to duplicate earlier motion based results. Details of this portion are included in a subsection of the pilot evaluation results. Testing was resumed following repair of the hydraulic pump.

Three pilots participated in the air-to-air simulation. All pilots flew the evaluations without turbulence or motion system disturbances. One pilot repeated his "calm air" evaluations with turbulence and motion system disturbances in order to examine the issue of motion coupling into the controllers. These evaluations are discussed in detail in Sections 13 and 14.

11. AIRCRAFT DYNAMICS AND CONTROLLER TEST MATRIX - The aircraft conventional and uncoupled mode dynamics were selected to be representative of capabilities which could be incorporated in next generation fighter aircraft. Each set of conventional dynamics was fine tuned for each task so as not to detract from the controller evaluations. Once a set of aircraft dynamics had been selected, these dynamics were held constant during that series of evaluations.

a. Air-To-Ground Dynamics - The conventional dynamics were chosen to be representative of a high performance fighter in a low level, high speed weapons delivery environment. As mentioned in Section 2, the short period frequency and damping were held constant throughout each run. However, the aircraft lift per angle of attack (N_Z/α) was varied proportionally with the change in dynamic pressure from the initial conditions. In order to provide a constant stick force per g, the stick gain was varied inversely with the change in dynamic pressure. In order to simulate an N_Z type command system, a value of angle of attack required for one g flight at current aircraft dynamic pressure

was continuously computed. Thus, regardless of airspeed or altitude, if the pilot neutralized the stick, the aircraft returned to a trimmed, one g flight condition. The pertinent characteristics were:

Initial conditions	V_{TRUE} = 520 knots @ 500 feet
Short period frequency	ω_{sp} = 6 Radians/second
Short period damping	ζ_{sp} = .8
Stick force per g	F_{Lon}/g = 3.0 lb/g
N_Z per angle of attack	N_Z/α = 52.6 g/Radian @ initial conditions
Max Longitudinal Stick Force	$F_{Lon_{max}}$ = 14 lbs.
Roll mode time constant	τ_r = .35 sec^{-1}
Max Roll Rate	P_{ss} = 150°/sec
Max Lateral Stick force	$F_{Lat_{max}}$ = 14 lb
Dutch Roll frequency	ω_d = 4.47 Rad/sec
Dutch roll damping	ζ_d = .68
Ny per sideslip angle	Ny/β = -5.73 g/Rad

The dutch roll characteristics were used only during the pre-simulation checkout. As previously mentioned, the model assumed perfect roll coordination such as not to excite the dutch roll mode. During the evaluations it was found to be best if the pedals were set as foot rests when not in use. The rudder pedals were the first uncoupled mode controller examined and often when the evaluations were moved to another controller, the pilots would instinctively find themselves trying to use the pedals instead of the designated controller. This could have some significance in proposed multi-mode control system designs where controllers change usage as a function of mode selection. Extensive pilot training may be required to minimize this problem.

(1) Wings Level Turn - The wings level turn mode was modeled as a first order yaw rate response as shown in Subsection 5 - AIRCRAFT MODEL DESCRIPTION. For the air-to-ground task an authority of 1 was used. At on-speed flight conditions this translates to a maximum steady state yaw rate of 2.15 degrees per second. A time constant of .5 sec was assumed appropriate. This is well within the level one guidelines recommended in References 26 and 44.

This results in a transfer function as shown in equation (1), and resulting Ny response shown in equation (2).

$$\frac{r_{WLT}}{\delta} = \frac{(r/\delta)_{WLT}}{\tau_{WLT}\ S + 1} = \frac{.00374}{.5\ s + 1} \quad (1)$$

$$Ny_{WLT} = V_{TRUE} \times r_{WLT} \quad (2)$$

In order to keep the maximum response at 1 g regardless of airspeed variation, the gain $(r/\delta)_{WLT}$ was scheduled as:

$$\frac{r}{\delta}\ WLT = \frac{r}{\delta}\ WLT_o \times \frac{V_{True_o}}{V_{True}} \quad (3)$$

where the subscript o denotes initial values.

The maneuver gradient (response per unit input) and breakout/deadband characteristic of the rudder pedals, twist grip sidestick, and thumb button controller were the experimental variables. The configurations evaluated are shown in Figures 26, 27 and 28.

Configuration No.	Breakout (lb)	Deadband (lb)	Maneuver Gradient (lb/g)	Maximum Force (Over Breakout) (lb)	Deflection at Maximum Force (in.)	Comments	No. of Evaluations	No. of Evaluation Pilots
1	7	0	15	15	0.5	Effect of Maneuver Gradient	1	1
2	↓	↓	25	25	↓		1	1
3	↓	↓	35	35	↓		1	1
4	↓	↓	45	45	↓		1	1
5	4	↓	25	25	↓	Effect of Breakout	1	1
6	10	↓	↓	↓	↓		1	1
7	20	↓	↓	↓	↓		1	1
8	7	↓	20	20	2	Effect of Maneuver Gradient	9	5
9	↓	↓	40	40	↓		8	5
10	↓	↓	60	60	↓		8	5
11	↓	↓	100	100	↓		6	5
12	4	↓	40	40	↓	Effect of Breakout	4	3
13	10	↓	↓	↓	↓		3	3
14	20	↓	↓	↓	↓		2	2

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Figure 26. Controller Characteristics Evaluated for Air-to-Ground Weapon Delivery
Wings Level Turn Mode Rudder Pedals

Configuration No.	Breakout (in.-lb)	Deadband (in.-lb)	Maneuver Gradient (in.-lb/g)	Maximum Torque (Over Deadband) (in.-lb)	Deflection at Maximum Torque (deg)	Comments	No. of Evaluations	No. of Evaluation Pilots
15	0	0.48	6	6	0.5	Effect of Maneuver Gradient	4	4
16			12	12	1.0		5	4
17			18	18	1.5		7	4
18			24	24	2.0		7	4
19			36	36	3.0		5	4
20			48	48	4.0		4	3
21		0.24	24	24	2.0	Effect of Deadband	1	1
22		0.72					1	1
23		2.40					1	1
24		4.80					1	1
25		0	36	36	3	Effect of Deadband	1	1
26		0.31					1	1
27		1.25					1	1
28		1.87					1	1
29		2.40					1	1
30		2.50					1	1
31		4.80					1	1
32		7.20					1	1
33		9.60					1	1
34		14.40					1	1

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Figure 27. Controller Characteristics Evaluated for Air-to-Ground Weapon Delivery
Wings Level Turn Mode Twist Grip Sidestick

Configuration No.	Breakout (lb)	Deadband (lb)	Maneuver Gradient (lb/g)	Maximum Force (Over Deadband) (lb)	Deflection at Maximum Force (in.)	Comments	No. of Evaluations	No. of Evaluation Pilots
36	0	0.025	0.833	0.833		Effect of Maneuver Gradient	1	1
37			1.000	1.000			2	1
38			1.250	1.250			4	4
39			1.667	1.667			9	4
40			2.500	2.500			4	4
41			5.000	5.000			7	3
42		0.075	1.667	1.667		Effect of Deadband	2	1
43		0.125					5	2
44		0.250					4	2
45		0.375					1	1
46		0.500					3	2

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Figure 28. Controller Characteristics Evaluated for Air-to-Ground Weapon Delivery
Wings Level Turn Mode Thumb Button Controller

(2) Fuselage Azimuth Aiming - The fuselage azimuth aiming mode was modeled as a second order response. For this portion of the simulation the maximum pointing authority was established at 10° of fuselage sideslip angle.

The frequency and damping were established at 5 rad/sec and 1.0 respectively. The resulting transfer function was:

$$\frac{\beta_{AA}}{\delta} = \frac{(\beta/S)_{AA}\, W_{AA}^{2}}{S^{2} + 2\zeta\, W_{AA}S + W^{2}_{AA}} = \frac{.01745\ (25)}{S^{2} + 50s + 25}$$

All terms were held constant during the run.

The same type of characteristics and controllers as used in the wings level turn evaluations were examined. These characteristics are shown in Figures 29 through 31.

b. Approach and Landing Dynamics - The approach configuration was developed with conventional response characteristics which may be representative of a STOL fighter configuration. The pertinent characteristics were:

Approach Speed	V_{app}	= 115 KCAS
Trim Angle of Attack	α_{TRIM}	= 12°
Angle of Attack/Stick Force	α/F_{LON}	= .92°/Lb.
Max Longitudinal Stick Force	$F_{LON_{MAX}}$	= 5.8 Lb Aft, 14 Lb fwd
Short Period Frequency	ω_{SP}	= 1.2 rad/sec
Short Period Damping	ζ_{SP}	= .7
Dutch Roll Frequency	ω_{DR}	= 1.2 rad/sec
Dutch Roll Damping	ζ_{DR}	= .7
Roll Mode Time Constant	τ_{r}	= .7 sec
Steady State Roll Rate	P_{SS}	= 50°/sec
Max Lateral Stick Force	$F_{LAT_{MAX}}$	= 14 Lb.

As with the air-to-ground configurations, the pilots were given coventional rudder controller only during the pre-evaluation checkout. The dutch roll transfer function was also used to inject turbulence in the directional axis. Additionally, a crossfeed between the directional and roll axis was established which provided 18.75 degrees per second of roll rate per radian of sideslip. This provided a roll disturbance model as well as α and β due to gusts.

Configuration No.	Breakout (lb)	Deadband (lb)	Maneuver Gradient (lb/deg)	Maximum Force (Over Breakout) (lb)	Deflection at Maximum Force (in.)	Comments	No. of Evaluations	No. of Evaluation Pilots
1	7	0	0.5	5	0.5	Effect of Maneuver Gradient	1	1
2			1.0	10			1	1
3			1.5	15			2	2
4			2.5	25			3	2
5			3.5	35			1	1
6			4.5	45			2	2
7			5.4	54			1	1
8	4		2.5	25		Effect of Breakout	1	1
9	10						1	1
10	20						1	1
11	7		2.0	20	2	Effect of Maneuver Gradient	2	2
12			4.0	40			3	3
13			6.0	60			6	4
14			10.0	100			6	5
15			14.0	140			6	5
16			18.0	180			3	3
17	4		4.0	40		Effect of Breakout	1	1
18	10						1	1
19	20						1	1
20	4		6.0	60		Effect of Breakout	2	2
21	10						1	1
22	20						2	2
23	38.5						2	2
24	4		10.0	100		Effect of Breakout	2	1
25	10						1	1
26	7		2.0	20	3	Effect of Maneuver Gradient	3	2
27			4.0	40			5	3
28			6.0	60			4	2
29			8.0	80			2	2
30			12.0	120			1	1
31			14.0	140			1	1
33			16.0	160			1	1

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Figure 29. Controller Characteristics Evaluated for Air-to-Ground Weapon Delivery Fuselage Azimuth Aiming Mode Rudder Pedals

Configuration No.	Breakout (in.-lb)	Deadband (in.-lb)	Maneuver Gradient (in.-lb/deg)	Maximum Torque (Over Deadband) (in.-lb)	Deflection at Maximum Torque (deg)	Comments	No. of Evaluations	No. of Evaluation Pilots
	0	0.48	1.2	12	1	Effect of Maneuver Gradient	3	3
	↓	↓	2.4	24	2		3	3
	↓	↓	3.6	36	3		4	3
	↓		4.8	48	4		5	3
38	↓	2.4	3.6	36	3	Effect of Deadband	2	2
39	↓	4.8	↓	↓	↓		2	2
40	↓	9.6	↓	↓	↓		2	2
41	↓	12.0	↓	↓	↓		2	2

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Figure 30. Controller Characteristics Evaluated for Air-to-Ground Weapon Delivery
Fuselage Azimuth Aiming Mode Twist Grip Sidestick

Configuration No.	Breakout (lb)	Deadband (lb)	Maneuver Gradient (lb/deg)	Maximum Force (Over Deadband) (lb)	Deflection at Maximum Force (in.)	Comments	No. of Evaluations	No. of Evaluation Pilots
42	0	0.025	0.500	5.00		Effect of Maneuver Gradient	1	1
43	↓	↓	0.250	2.50			1	1
44	↓	↓	0.167	1.67			1	1
45	↓	0.025	0.750	5		7.5 deg Authority	1	1
46	↓	↓	1.000	↓		5 deg Authority	1	1

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Figure 31. Controller Characteristics Evaluated for Air-to-Ground Weapon Delivery
Fuselage Azimuth Aiming Mode Thumb Button Controller

The level of turbulence and crosswind utilized were based on the capabilities of the conventional aircraft. In calm air the above dynamics resulted in level one flying qualities ratings. The pilots found the configuration easy to control. As the turbulence level increased above 5 feet per second rms in pitch and yaw the flying qualities degraded to level two. A value of 3 feet per second was chosen for the remainder of the simulation.

A similar process was used in determining the amount of crosswind. For crosswinds in excess of 20 knots, the flying qualities of the conventional aircraft degraded to level two even without turbulence. Wing low, cross-controlled approaches were fatiguing due to the lateral-directional coupling. In wind speeds greater the 20 knots the pilots found the crab angle to be disconcerting if left in at touchdown. One pilot questioned whether gear strength would be high enough.

The selected values of 3 feet per second turbulence and 15 knot shearing wind resulted in level one ratings with the conventional response. Pilot comments however indicated that the workload was quite high. These were felt to be the best combination to use for the uncoupled mode evaluations.

Three lateral uncoupled mode responses were evaluated: wings level turn, lateral translation, and fuselage azimuth aiming. Limited evaluations were conducted using vertical translation in conjunction with some of the lateral modes.

The wings level turn mode was modeled exactly as in the air-to-ground evaluations. For approach the authority was limited to .2 g and the time constant (τ_{WLT}) was set to .65 sec. The same scaling was used on the wings level turn gain to provide a constant Ny capability with changing airspeed.

The lateral translation mode was mechanized as a first order response with .2 g initial acceleration capability. The maximum sideslip that could be generated was 6.67 degrees. This resulted in a mode time constant of 3.5 sec.

The azimuth pointing mode was also mechanized as in the air-to-ground evaluations. The mode authority was limited to 6.67 degrees and the frequency and damping set to 2.0 rad/sec and .8 respectively.

A simplified speed hold system was mechanized by not modeling any induced drag due to angle of attack. Airspeed variations were greatly reduced even though it would still change with changes in aircraft flight path angle. This greatly simplified the pilots airspeed control task. Pilot comments indicated this played a major role in the acceptability of the aircraft response characteristics.

Four controllers were evaluated with these modes in the landing task. The controllers included rudder pedals, twist grip sidestick, thumb button and a left hand operated thumbwheel. Details of each configuration are shown in Figures 32 through 38. Note that no configurations are shown for the thumbwheel controller. The configurations examined will be discussed in Section 12.

Configuration No.	Breakout (lb)	Deadband (lb)	Maneuver Gradient (lb/g)	Maximum Force (Over Breakout) (lb)	Deflection at Maximum Force (in.)	Comments	No. of Evaluations	No. of Evaluation Pilots
1	7	0	25	5	0.5	Effect of Maneuver Gradient	2	2
2			50	10			2	2
3			75	15			2	2
4			125	25			3	2
5			175	35			2	2
6			225	45			2	2
7			270	54			2	2
8	4		125	25		Effect of Breakout	1	1
9	10						2	2
10	20						1	1
11	38.5						1	1
12	7		100	20	2	Effect of Maneuver Gradient	4	3
13			200	40			2	2
14			300	60			3	3
15			500	100			2	2
16			700	140			1	1
17	4		200	40		Effect of Breakout	2	2
18	10						2	2
19	20						1	1
20	7		100	20	3	Effect of Maneuver Gradient	1	1
21			200	40			2	1
22			300	60			1	1
23			400	80			1	1
24			500	100			1	1

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Figure 32. Controller Characteristics Evaluated for Approach and Landing
Wings Level Turn Mode Rudder Pedals

Configuration No.	Breakout (in.-lb)	Deadband (in.-lb)	Maneuver Gradient (in.-lb/g)	Maximum Torque (Over Deadband) (in.-lb)	Deflection at Maximum Torque (deg)	Comments	No. of Evaluations	No. of Evaluation Pilots
25	0	0.48	30	6	0.50	Effect of Maneuver Gradient	1	1
26			40	8	0.667		2	2
27			60	12	1.00		2	2
28			90	18	1.50		1	1
29			120	24	2.00		2	2
30			180	36	3.00		1	1
31			240	48	4.00		2	1
32		2.40	40	8	0.667	Effect of Deadband	2	1
33		9.60					1	1
34		14.40					1	1
35		4.80	60	12	1.00	Effect of Deadband	1	1
36		9.60					1	1
37		4.80	120	24	2.00	Effect of Deadband	1	1

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Figure 33. Controller Characteristics Evaluated for Approach and Landing
Wings Level Turn Mode Twist Grip Sidestick

Configuration No.	Breakout (lb)	Deadband (lb)	Maneuver Gradient (lb/g)	Maximum Force (Over Deadband) (lb)	Deflection at Maximum Force (in.)	Comments	No. of Evaluations	No. of Evaluation Pilots
38	0	0.05	2.50	0.500		Effect of Maneuver Gradient	1	1
39			3.13	0.626			1	1
40			4.17	0.834			1	1
41			5.00	1.00			1	1
42			8.33	1.67			1	1
43			12.50	2.50			1	1
44			25.00	5.00			2	1
45		0.025	5.00	1.00		Effect of Deadband	1	1
46		0.250					1	1
47		0.750					1	1

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Figure 34. Controller Characteristics Evaluated for Approach and Landing
Wings Level Turn Mode Thumb Button Controller

Configuration No.	Breakout (lb)	Deadband (lb)	Maneuver Gradient (lb/deg)	Maximum Force (Over Breakout) (lb)	Deflection at Maximum Force (in.)	Comments	No. of Evaluations	No. of Evaluuation Pilots
1	7	0	2.24	15	0.5	Effect of Maneuver Gradient	1	1
2			5.22	35			1	1
3			1.49	10	2.0	Effect of Maneuver Gradient	1	1
4			2.99	20			3	3
5			5.97	40			3	2
6			8.96	60			2	2
7			14.9	100			2	2

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Figure 35. Controller Characteristics Evaluated for Approach and Landing
Fuselage Azimuth Aiming Mode Rudder Pedals

Configuration No.	Breakout (in.-lb)	Deadband (in.-lb)	Maneuver Gradient (in.-lb/deg)	Maximum Torque (Over Deadband) (in.-lb)	Deflection at Maximum Torque (deg)	Comments	No. of Evaluations	No. of Evaluation Pilots
8	0	0.72	1.19	8	0.67	Effects of Maneuver Gradient and Deadband	1	1
9			1.79	12	1.00		1	1
10			3.58	24	2.00		1	1
11		4.80	1.79	12	1.00		1	1
12		9.60	1.19	8.0	0.67		1	1
13			1.43	9.6	0.80		1	1

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Figure 36. Controller Characteristics Evaluated for Approach and Landing
Fuselage Azimuth Aiming Mode Twist Grip Sidestick

Configuration No.	Breakout (lb)	Deadband (lb)	Maneuver Gradient (lb/deg)	Maximum Force (Over Breakout) (lb)	Deflection at Maximum Force (in.)	Comments	No. of Evaluations	No. of Evaulation Pilots
1	7	0	0.75	5	0.5	Effect of Maneuver Gradient	1	1
2			2.24	15			1	1
3			3.73	25			1	1
4			5.22	35			3	2
5			6.72	45			3	2
6			8.06	54			2	2
7			2.98	20	2.0	Effect of Maneuver Gradient	2	2
8			5.97	40			2	2
9			8.95	60			2	2

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Figure 37. Controller Characteristics Evaluated for Approach and Landing
Lateral Translation Mode Rudder Pedals

Configuration No.	Breakout (in.-lb)	Deadband (in.-lb)	Maneuver Gradient (in.-lb/deg)	Maximum Torque (Over Deadband) (in.-lb)	Deflection at Maximum Torque (deg)	Comments	No. of Evaluations	No. of Evaluation Pilots
10	0	0.48	1.78	11.9	0.99	Effects of Maneuver Gradient and Deadband	1	1
11			2.67	17.9	1.49		1	1
12			5.34	35.8	2.98		1	1
13		0.72	1.07	7.2	0.60		1	1
14			1.34	9.0	0.75		1	1

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Figure 38. Controller Characteristics Evaluated for Approach and Landing
Lateral Translation Mode Twist Grip Sidestick

c. Air-To-Air Tracking Dynamics - To minimize learning effects and provide continuity with the previously obtained data, we had planned to use the same flight conditions, aircraft dynamics, and authorities used previously in the air-to-ground tasks. However, it became apparent in checkout that the pitch axis was too sensitive for very precise air-to-air tracking. The initial value of stick force gradient was 3.0 lb/g, and the short period frequency was 6.0 rad/sec. The stick force per g had been a compromise value determined by the 3-4 g's required for the pop-up-maneuver used in the air-to-ground tasks and the 12 lb maximum input capability of the sidestick controller. Alternate values of 5.0 and 7.0 pounds per g were tried. While the 7.0 lb/g case produced the least sensitivity, the force required to track a 2 g turning target was considered excessive. Using the 5.0 lb/g gradient, short period frequencies of 2, 4, 5, and 6 radians per second were evaluated. The 5.0 radian per second value was selected as the best compromise for quickness and sensitivity. The flight condition and aircraft dynamics used were:

Mach = .8 Altitude = 1000 feet V_{True} = 520 knots

Longitudinal Dynamics

N_z per α	= 52.60 g/rad
Short Period Frequency	= 5.00 rad/sec
Short Period Damping	= .80
Stick Force per g	= 5.00 lb/g

Lateral Dynamics

Roll mode time constant	= .35 sec
Roll rate per lb stick force	= 12.5 deg/sec/lb
Max Roll Rate	= 150 deg/sec

Wings Level Turn Dynamics (WLT)

WLT time constant	= .500 sec
Maximum Ny	= 1 g for all controllers

The same comments made previously for gain scheduling and the use of directional dynamics discussed in the air-to-ground discussions apply to the air-to-air configurations. The rudder pedals, twist grip sidestick and thumb controllers were examined. The specific configurations are shown in Figures 39 through 41.

Configuration No.	Breakout (lb)	Deadband (lb)	Maneuver Gradient (lb/g)	Maximum Force (Over Breakout) (lb)	Deflection at Maximum Force (in.)	Comments	No. of Evaluations	No. of Evaluation Pilots
1	7	0	20	20	1	Effect of Maneuver Gradient	1	1
2			40	40			2	2
3			60	60			2	2
4	4		20	20		Effect of Breakout	1	1
5	10						1	1
6	15						1	1
7	15		60	60		Effect of Breakout	1	1
8	20						1	1
9	25						1	1
10	7		20	20	2	Effect of Maneuver Gradient	8	3
11			40	40			9	3
12			60	60			8	3
13	4		20	20		Effect of Breakout	1	1
14	10						1	1
15	15						1	1
16	25						1	1
17	1.5*		40	40		Effect of Breakout	1	1
18	4						6	3
19	10						4	3
20	15						6	3
21	20						3	2
22	25						2	2
23	7		20	20	3	Effect of Maneuver Gradient	1	1
24			40	40			2	1
25			60	60			3	2
26	4		60	60		Effect of Breakout	1	1
27	10						2	2
28	15						2	2
29	20						2	2

*Due to friction only

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Figure 39. Controller Characteristics Evaluated for Air-to-Air Tracking
Wings Level Turn Mode Rudder Pedals

Configuration No.	Breakout (in.-lb)	Deadband (in.-lb)	Maneuver Gradient (in.-lb/g)	Maximum Torque (Over Deadband) (in.-lb)	Deflection at Maximum Torque (deg)	Comments	No. of Evaluations	No. of Evaluation Pilots
30	0	0.48	12	12	1	Effect of Maneuver Gradient	9	3
31	↓	↓	24	24	2		16	3
32	↓	↓	36	36	3		7	3
33	↓	2.7	12	12	1	Effect of Deadband	1	1
34	↓	4.8	↓	↓	↓		1	1
35	↓	7.5	↓	↓	↓		1	1
36	↓	2.7	24	24	2	Effect of Deadband	6	3
37	↓	4.8	↓	↓	↓		6	3
38	↓	7.2	↓	↓	↓		1	1
39	↓	7.5	↓	↓	↓		3	2
40	↓	9.6	↓	↓	↓		2	1

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Figure 40. Controller Characteristics Evaluated for Air-to-Air Tracking
Wings Level Turn Mode Twist Grip Sidestick

Configuration No.	Breakout (lb)	Deadband (lb)	Maneuver Gradient (lb/g)	Maximum Force (Over Deadband) (lb)	Deflection at Maximum Force (in.)	Comments	No. of Evaluations	No. of Evaluation Pilots
41	0	0.05	1.25	1.25		Effect of Maneuver Gradient	5	3
42	↓	↓	2.50	2.50			5	3
43	↓	↓	3.33	3.33			7	3
44	↓	↓	5.00	5.00			7	3
45	↓	0.5	3.33	3.33		Effect of Deadband	5	3
46	↓	1.0	↓	↓			5	3
47	↓	1.5	↓	↓			4	1
48	↓	0.5	5.00	5.00		Effect of Deadband	1	1
49	↓	1.0	↓	↓			1	1
50	↓	1.5	↓	↓			1	1

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Figure 41. Controller Characteristics Evaluated for Air-to-Air Tracking
Wings Level Turn Mode Thumb Button Controller

12. PILOT SUBJECTIVE AND PERFORMANCE RESULTS - The following sections contain the results of the pilot subjective evaluations and available performance results. The discussion will be broken down by task and controlled mode. For the air-to-ground and approach and landing the pilots will be identified by numbers indicating their initial order of participation. The air-to-air evaluation was broken into two simulation periods. All of the air-to-air pilots had participated in a previous portion of the simulation. The air-to-air pilots are identified by a two digit code which has nothing to do with the number or order of pilot participation.

Some discussion of the use of the Cooper-Harper rating scale is in order before discussing the simulation results. After each configuration had been examined, the pilots used a Cooper-Harper rating card to assist in determining a rating. A copy of this card and a card listing specific areas to be commented on were available in the cockpit at all times. The pilots were encouraged to talk their way through the rating card starting at the lower left and working their way up the scale. Half pilot ratings were not allowed. While it is felt this procedure helped in the consistency of the pilot ratings, it appears to have resulted in a non-linear use of the ratings scale. Pilot comments indicate that the handling qualities degradation was greater between Cooper-Harper ratings (CH) across handling quality levels than between ratings within a given level. For example, a degradation from a CH=3 to a CH=4 is more significant than a decrease from CH=2 to CH=3.

a. Air-to-Ground Weapons Delivery - During this phase of the simulation, the Wings Level Turn (WLT) and Fuselage Azimuth Aiming (FAA) modes were examined. The specific tasks used to evaluate the controller variations were described in detail in Section 10 - SIMULATION TASKS, DISPLAYS, AND PERFORMANCE MEASURES. As discussed in this section, the strafing task using the pop-up maneuver was the primary air-to-ground evaluation task.

For each mode three controllers were evaluated: rudder pedals, the twist grip sidestick controller, and a thumb button controller mounted on top of the sidestick. The rudder pedals were tested at various maneuver gradients, breakouts, and maximum deflections. The twist grip and thumb controller were tested with various maneuver gradients and deadbands. For each variation flown the pilots were asked to give a Cooper-Harper rating and comments on specific characteristics as described on the comment card in the cockpit.

(1) Wings Level Turn - The air-to-ground/wings level turn pilot rating data is presented in Figures 42 through 49. Only one pilot examined the half-inch deflection pedals. As Figure 43 indicates, the pilot was fairly insensitive to variations in breakout forces. The reader is cautioned, however, to reference

earlier comments on the non-linear use of the scale. This non-linearity manifests itself as a larger change in flying qualities when going from a Cooper-Harper (CH) rating of 3 to CH=4 than a change from CH=2 to CH=3 would represent. Pilot ratings for the 2" rudder pedal deflection are shown in Figures 44 and 45. In these and the following figures, if a pilot evaluated a configuration more than once, the average of the ratings was plotted. Vertical brackets were then added to indicate the range of the ratings. Pilot 6 evaluated the 20 lb/g maneuver gradient of the 2" rudder pedals two times. His first rating was CH=7. Later, after evaluating several other configurations, the configuration was re-examined and assigned a CH=4. The averaging technique results in a point placed at CH=5 1/2 with vertical bars extending from CH=4 to CH=7. The numeral 2 annotated to the point indicates that two ratings were used in this average. The results of the maneuver gradient and deadband variations for the twist grip sidestick are shown in Figures 46 and 47. The ratings from the thumb controller evaluations are illustrated in Figures 48 and 49.

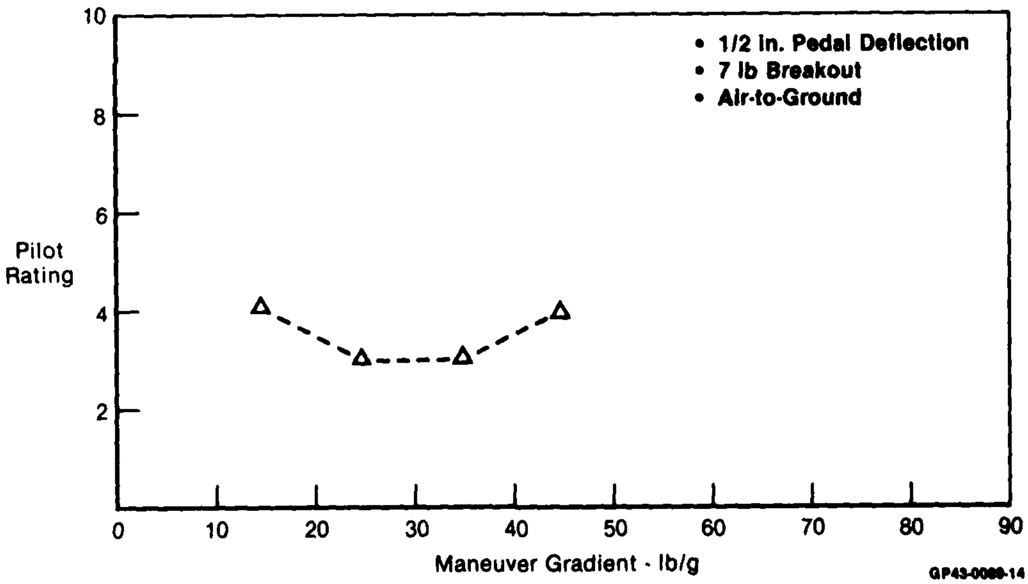

Figure 42. Pilot Rating vs Maneuver Gradient
Rudder Pedals Wings Level Turn Pilot 8

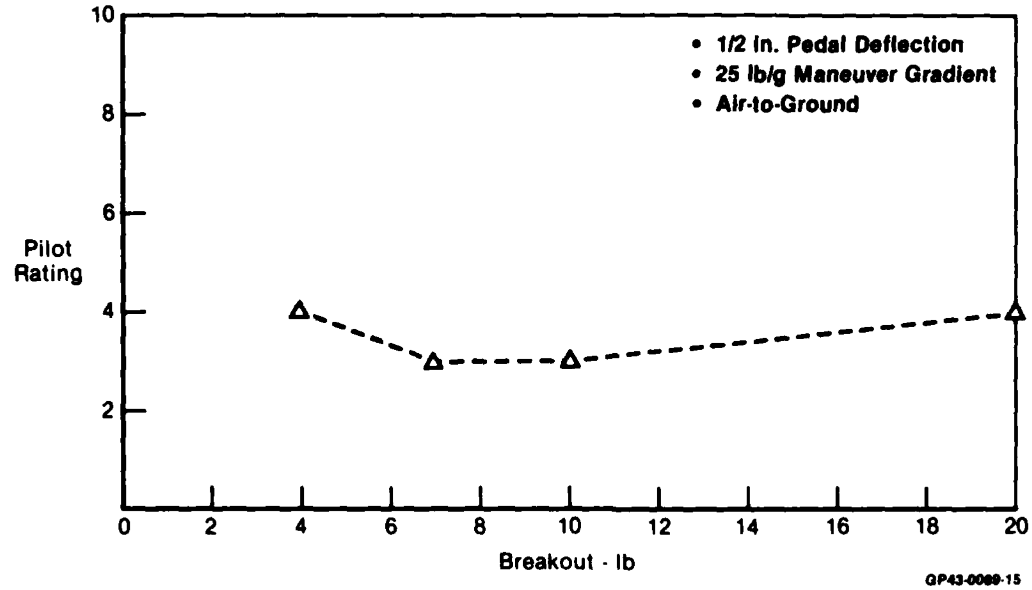

Figure 43. Pilot Rating vs Breakout
Rudder Pedals Wings Level Turn Pilot 8

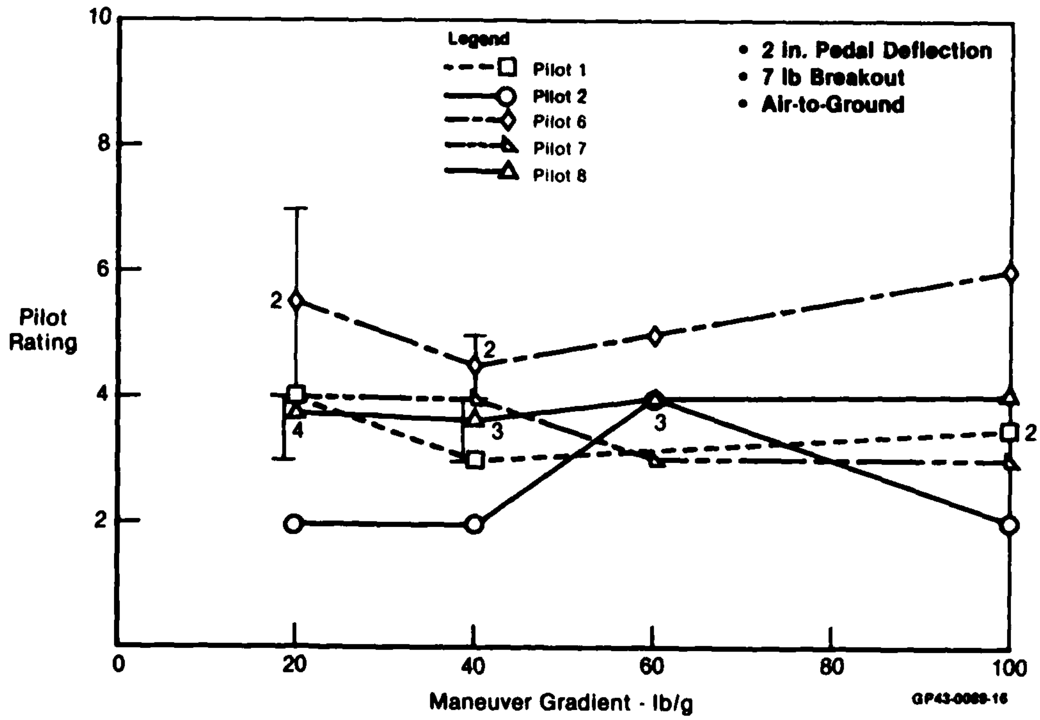

Figure 44. Pilot Rating vs Maneuver Gradient
Rudder Pedals Wings Level Turn

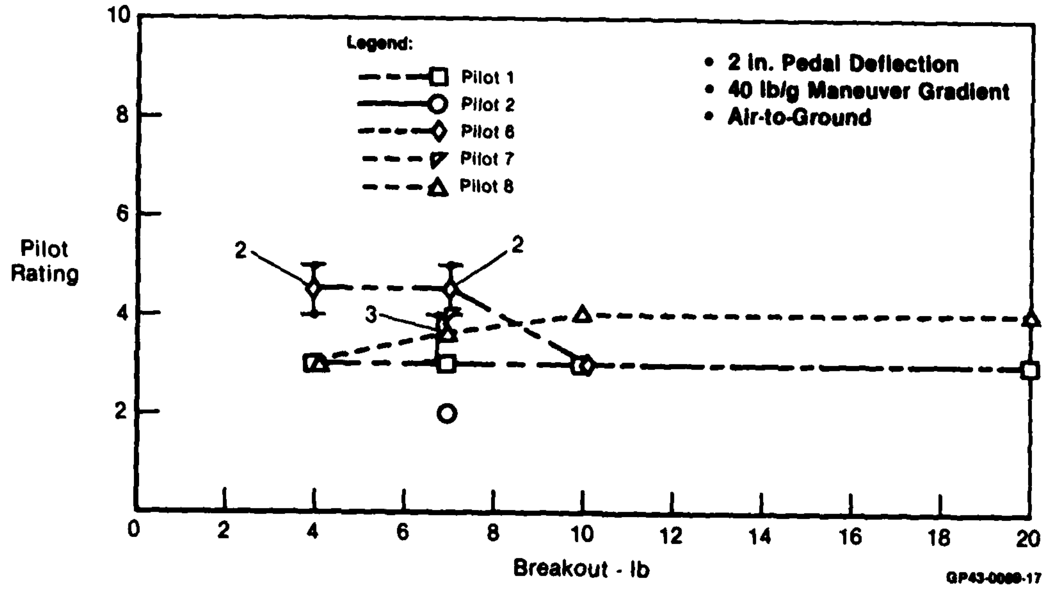

Figure 45. Pilot Rating vs Breakout
Rudder Pedals Wings Level Turn

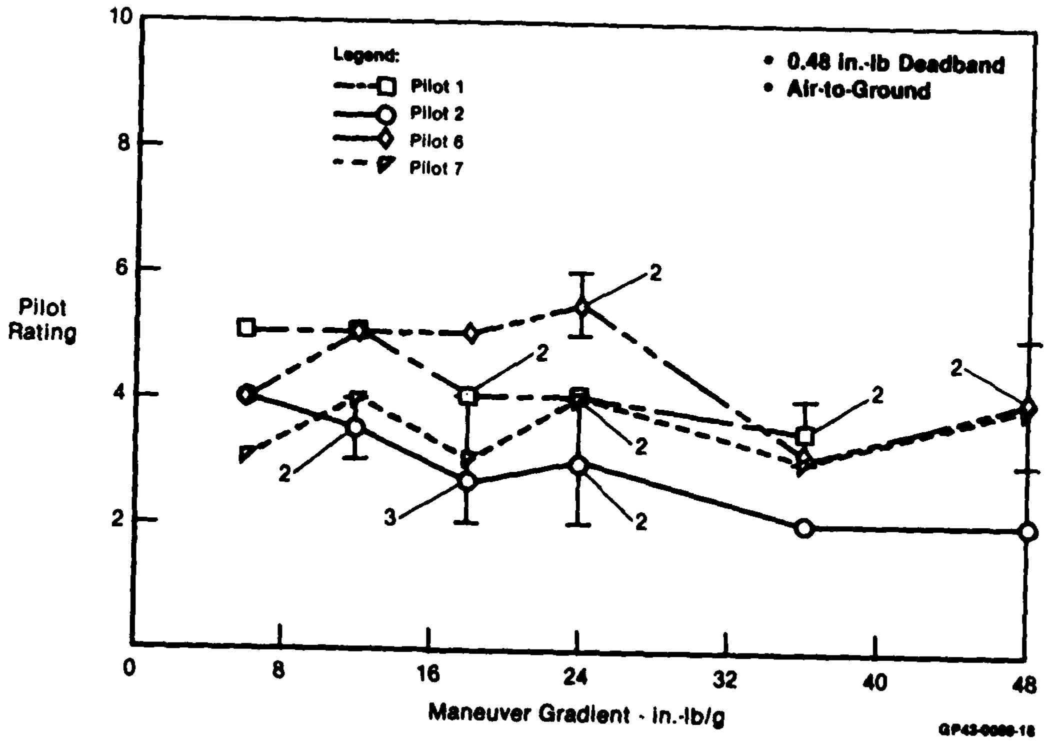

Figure 46. Pilot Rating vs Maneuvering Gradient
Twist Grip Sidestick Wings Level Turn

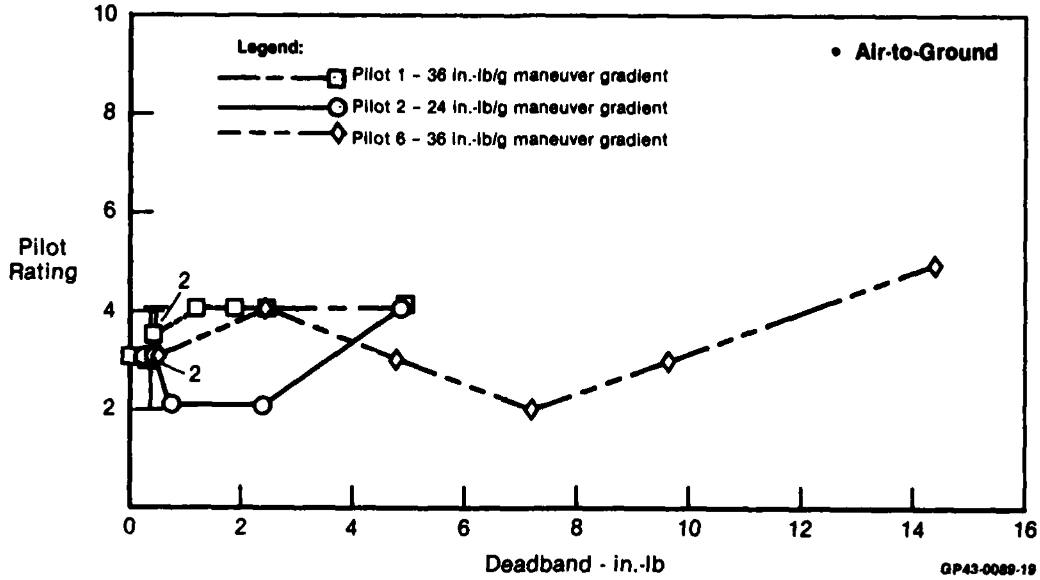

Figure 47. Pilot Rating vs Deadband
Twist Grip Sidestick Wings Level Turn

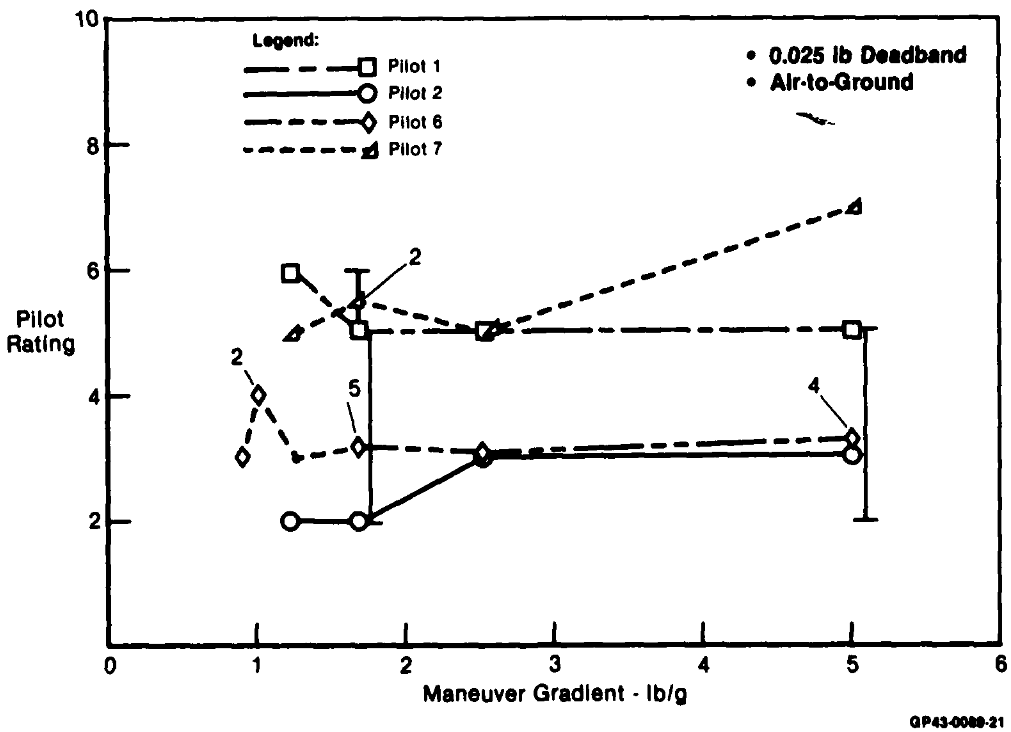

Figure 48. Pilot Rating vs Maneuver Gradient
Thumb Button Controller Wings Level Turn

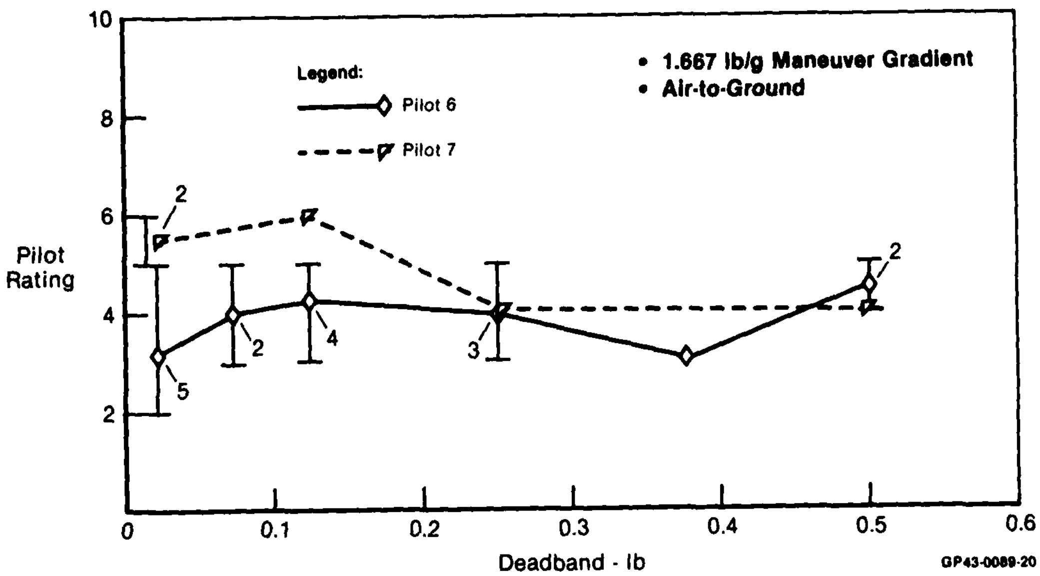

Figure 49. Pilot Rating vs Deadband
Thumb Button Controller Wings Level Turn

Examination of the wings level turn data indicates no clear trend for desired maneuver gradients for any of the controllers examined. In addition, there is no apparent preference for one pedal displacement over another. Breakout or deadband variation had little effect on pilot rating. These data indicate a lack of definite trend for controller sensitivity. Reference 44 reported similar results.

Several interesting observations were made during the wings level turn evaluations. The pilots all commented on the ease with which they adapted to using the wings level turn. Several of the pilots commented that it was much easier to stabilize on the target using the uncoupled mode than using only the conventional aircraft response. The pilots were unanimous in selecting the rudder pedals as their favored controller. These were followed by the twist grip sidestick with the thumb controller finishing last. The major objections to the twist grip and thumb button controllers dealt mainly with coupling problems. These problems generally were manifested as cross-axis coupling between wings-level turn control and roll control. A few incidences of pitch coupling were noted with the twist grip controller. One pilot commented on the difficulty of maintaining a thumb controller command while simultaneously squeezing the trigger. Another pilot commented that the thumb button would require designation of a new weapon release switch for bombing or firing missiles since the task is presently initiated by depressing a button to release stores. Considerable retraining might therefore be necessary.

Observation of the simulation runs indicated that the pilots showed a tendency to roll to the left more than to the right. The pilots had been instructed to always roll towards the target in an attempt to alleviate this tendency. However this suggestion was not always followed. Some pilots adopted an interesting technique to compensate for rolling away from the target. If, when pulling through the horizon in the invert portion of the pop-up, the pilot found himself to the left of the target, he would initiate a left roll. As the aircraft passed through the 90° bank angle position, he would apply nose right wings level turn command. By the time the aircraft reached the wings level position, a portion of the offset had already been removed and a high rate of wings level turn command was already in effect. Thus the pilots used the wings level turn to compensate for the offset rather than roll towards the target. When questioned about the technique, the pilots indicated they were unaware of what they were doing, that it just seemed the natural thing to do. This technique was only observed to any great extent when the rudder pedals were being used for wings level turn command.

It became apparent from observing the runs and talking to the pilots during the debriefing that they tended to make corrections one axis at a time. Examination of cross plots of the pitch, roll, and wings level turn commands confirmed this phenomenon. Cross plots for Pilot 6 using the rudder pedals for wings level turn are shown in Figures 50, 51 and 52. In Figure 50 the percent of roll rate command is plotted along the abscissa with percent wings level turn command plotted along the ordinate. This configuration was well liked by the pilot and received a CH=2 rating. Notice the almost total separation of control inputs. Figure 51 presents percent pitch command along the abscissa witl. percent wings level turn command as the ordinate. Again we see an almost total separation of control inputs. In both these figures note the amount of wings level turn command activity and that these commands are between 40 and 60 percent of the 1g maximum command. Roll rate versus pitch commands are shown in Figure 52. Again we see a separation of control inputs. It should be mentioned at this point that the pitch and roll axis had zero breakout and approximately .2 pounds of deadband.

Next we will examine a twist grip-wings level turn evaluation by the same pilot. The configuration was 36 in-lb per g maneuver gradient with a .48 in-lb deadband. Cross plots of percent wings level turn and roll rate commands are shown in Figure 53. Note the apparent cross coupling in both axes and the reduced wings level turn command activity. At the maximum applied roll rate command, achieved during the roll portions of the pop-up maneuver, there is approximately a 20 percent wings level turn command. The pilot had very few negative comments about the configuration and assigned a CH=3 rating. It should be noted however that the wings level turn to roll rate coupling occurred at a time when the pilot did not have visual contact with the terrain board. Also note that the roll rate due to wings level turn command was between 5 percent and 15 percent of the maximum roll rate command.

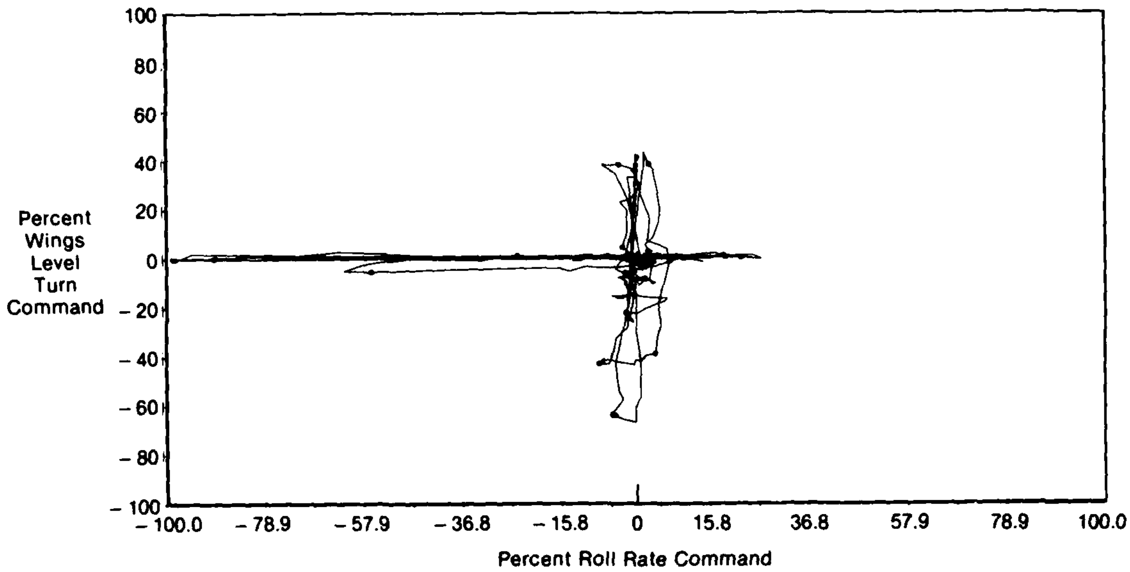

Figure 50. Wings Level Turn Command vs Roll Rate Command
Rudder Pedals Percent of Maximum

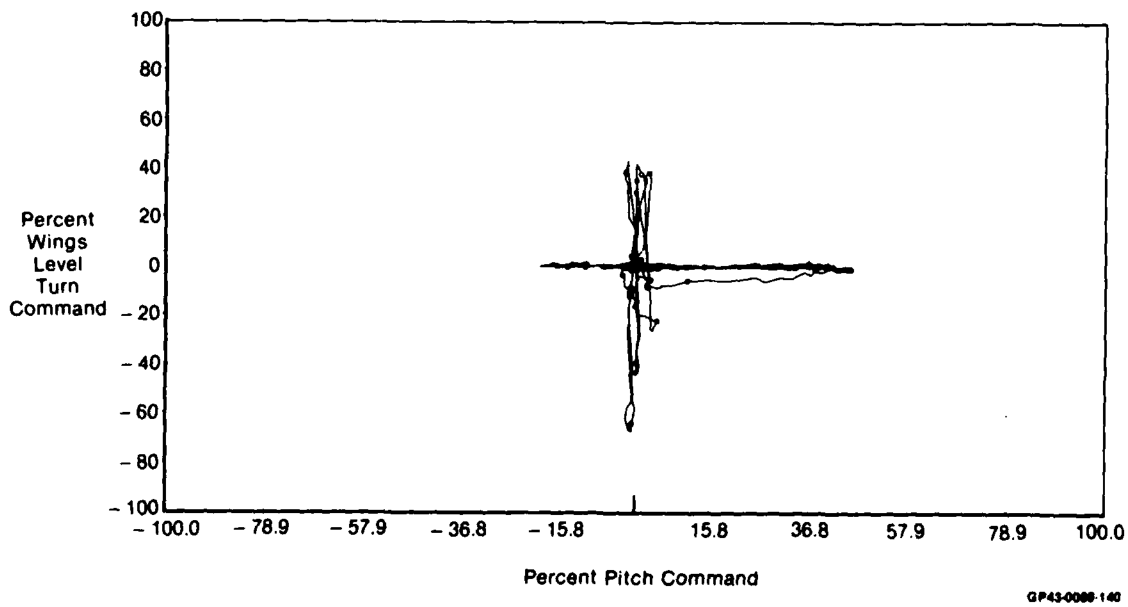

Figure 51. Wings Level Turn Command vs Pitch Command
Rudder Pedals Percent of Maximum

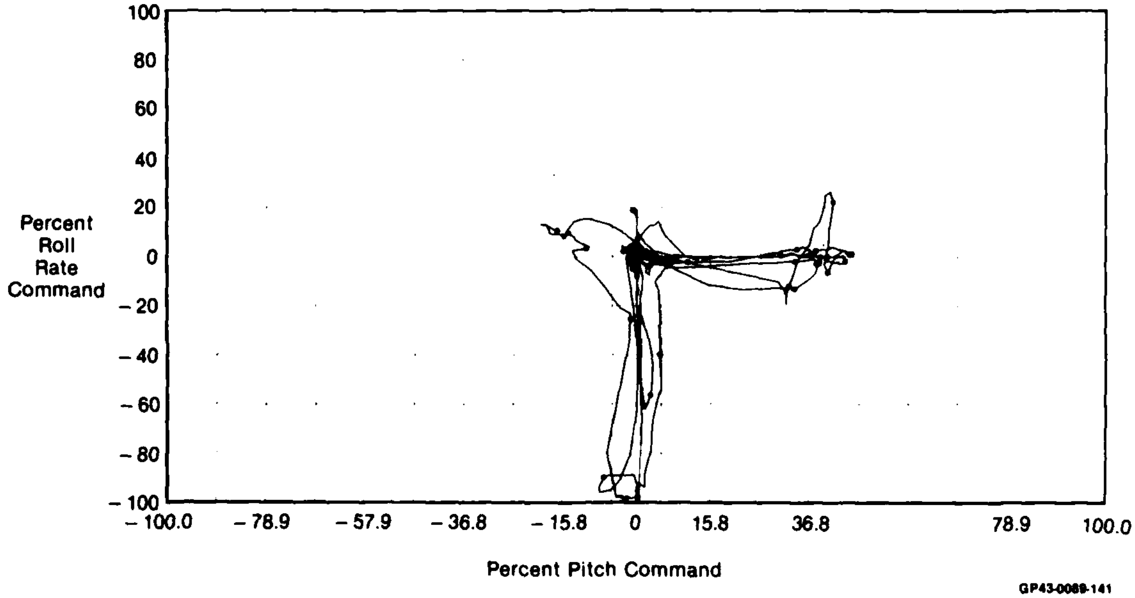

Figure 52. Roll Rate Command vs Pitch Command
Rudder Pedals Percent of Maximum

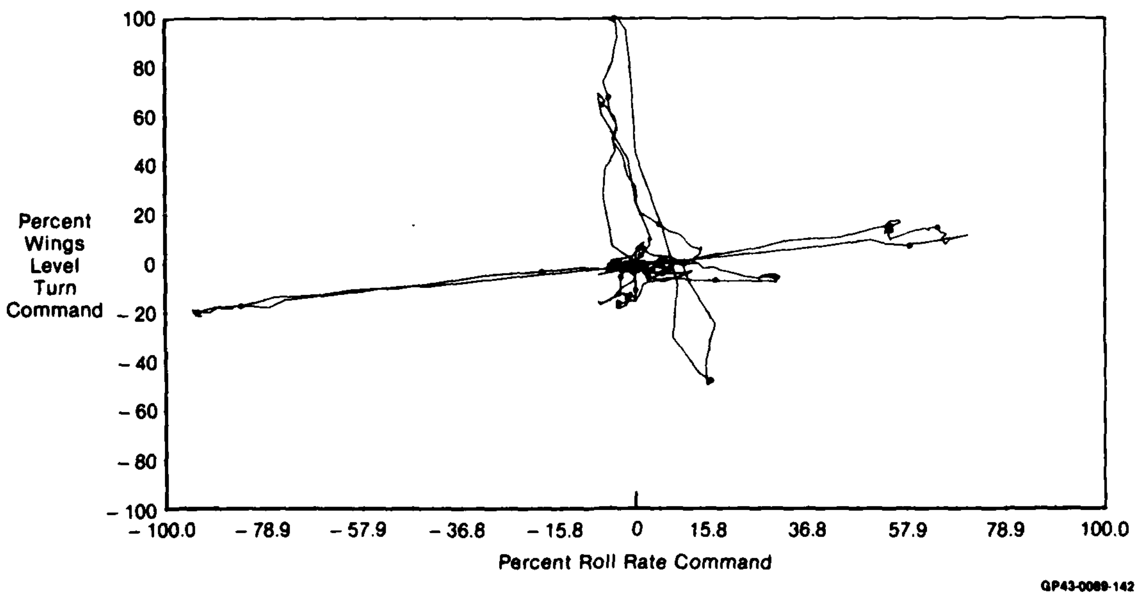

Figure 53. Wings Level Turn Command vs Roll Rate Command
Twist Grip Sidestick 0.48 In.-Lb Deadband Percent of Maximum

Based on the information presented in Figure 53, it appears that the wings level turn command to roll rate command coupling could be eliminated by increasing the twist grip deadband to approximately 7.5 in-lb of torque. Examination of Figure 54 indicates this is indeed the case. The configuration was the same 36 in-lb per g maneuver gradient with a 7.2 in-lb deadband. Coupling of the roll rate command into the wings level turn command is eliminated except at the maximum roll rate command when the controller is on the left stop. The wings level turn command is between 60 and 90 percent of the maximum available. Compared with the rudder pedal inputs of Figure 50, it would appear that there is some coupling between wings level turn commands and roll rate commands. This coupling is however somewhat more difficult to quantify since these inputs are during the final target acquisition and tracking. It is not possible to precisely determine how much of the roll rate activity is due to coupling and how much is due to desired pilot inputs. Apparently the coupling was not too severe since the pilot assigned a CH=2 to this configuration.

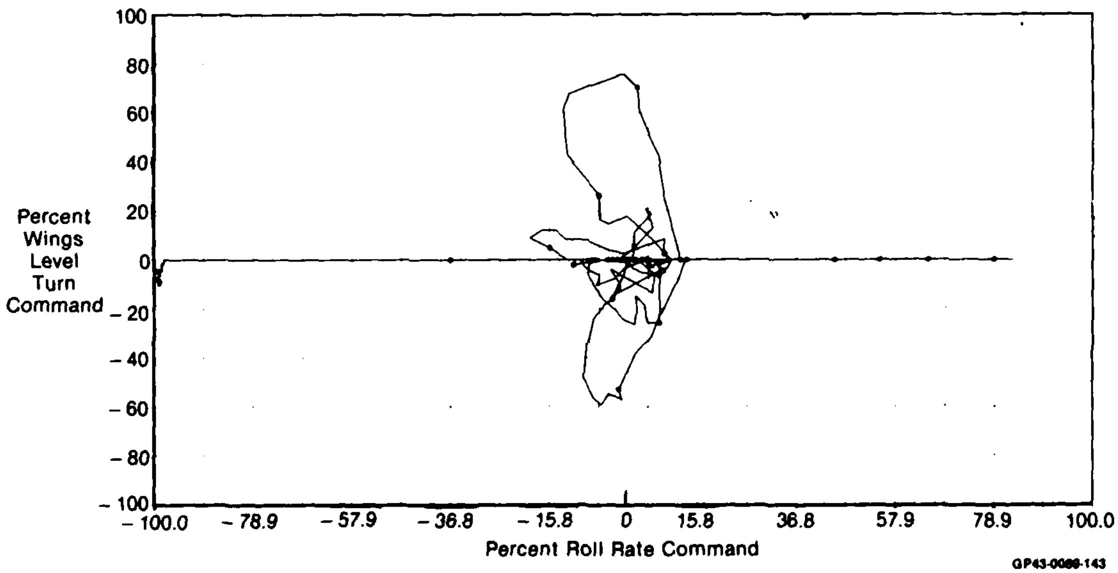

Figure 54. Wings Level Turn Command vs Roll Rate Command
Twist Grip Sidestick 7.2 In.-Lb Deadband Percent of Maximum

Pilot technique changed when using the thumb button controller. Pilot 6 found that he had difficulty making button inputs without coupling into the roll axis. For this reason he appears to have modified his control technique to using discrete button inputs and estimating the amount of lead to stop the gun cross on the target. This technique is indicated by the following excerpt taken from the voice tapes recorded during the simulation.

"Well, I've been using it more as an on/off, bang-bang type controller than anything else. I assume these are 300 foot wide runways here. If you are just going between two sides of the runways you don't need the full command authority. I don't think I've been using full command authority, but to get it onto the target initially, it's just full deflection until it's about maybe 100 feet away and then I cut the controller and let it drift over there and settle down on the target."

This technique is graphically illustrated in Figure 55. As would be expected, there is no apparent coupling between roll rate commands and wings level turn commands. However, it is apparent that roll rate commands are present during the wings level turn inputs. Notice also that there are only two high authority wings level turn commands. From Figure 56 it appears that the wings level turn commands also couple into the pitch axis. It is difficult to say that these pitch and roll inputs are definitely due exclusively to coupling since these inputs occur during target acquisition and tracking, although based on the pilot comments the probabilities are quite high that this is the case. The increased combined axis inputs shown in Figure 57 lead the observer to believe that the pilot is using more of the conventional response to solve the tracking problem than he had with other controllers. The button was configured with a 5.0 pound per g maneuver gradient and a .025 pound deadband. The pilot assigned the configuration a CH=3.

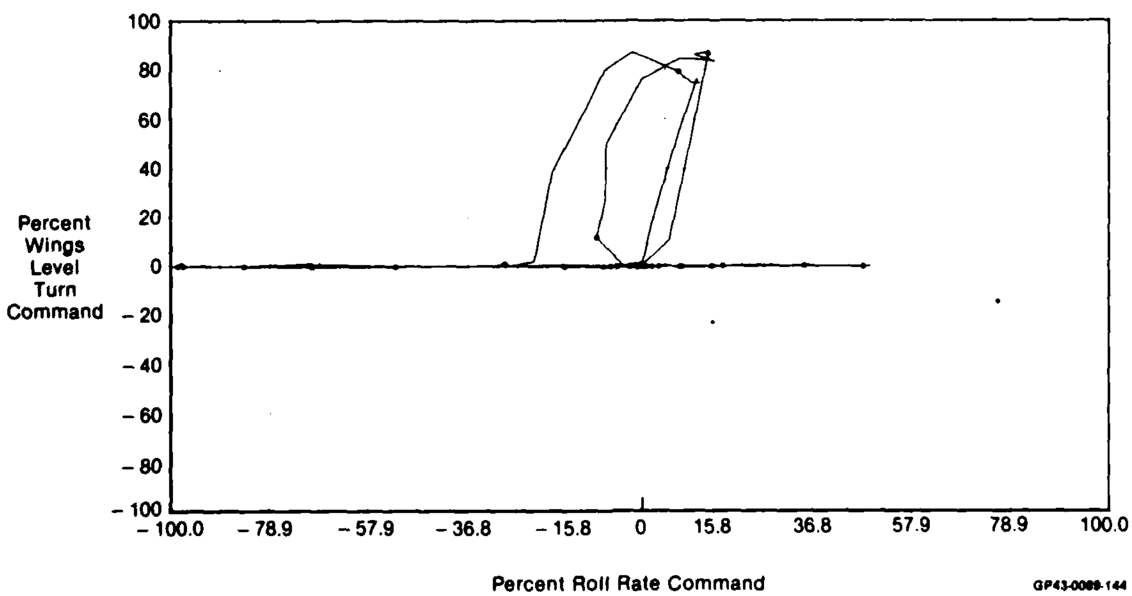

Figure 55. Wings Level Turn Command vs Roll Rate Command
Thumb Button Controller   Percent of Maximum

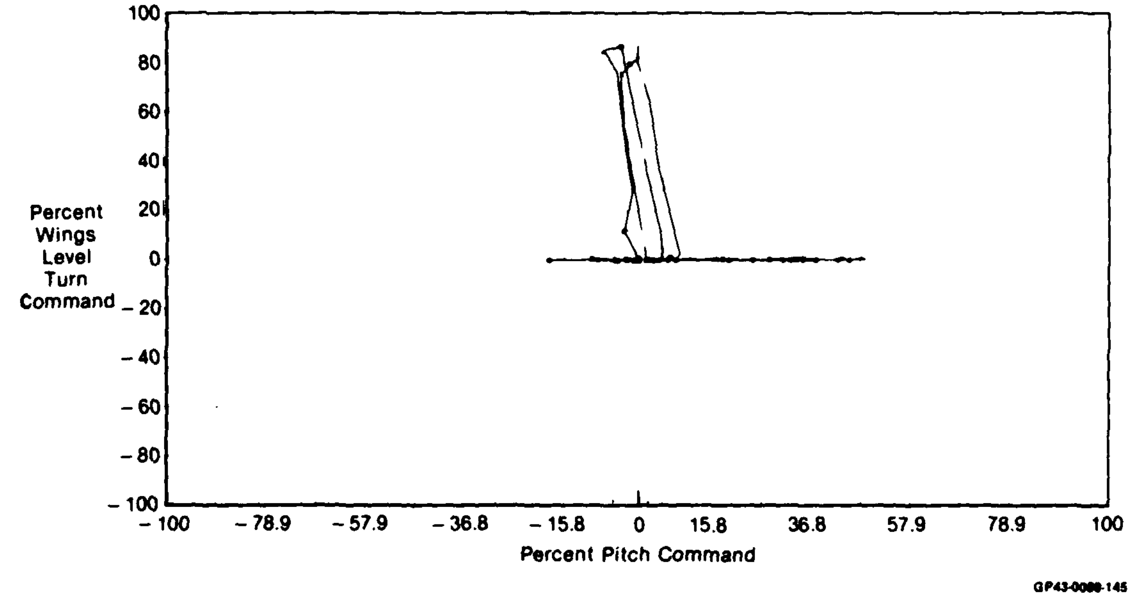

Figure 56. Wings Level Turn Command vs Pitch Command
Thumb Button Controller   Percent of Maximum

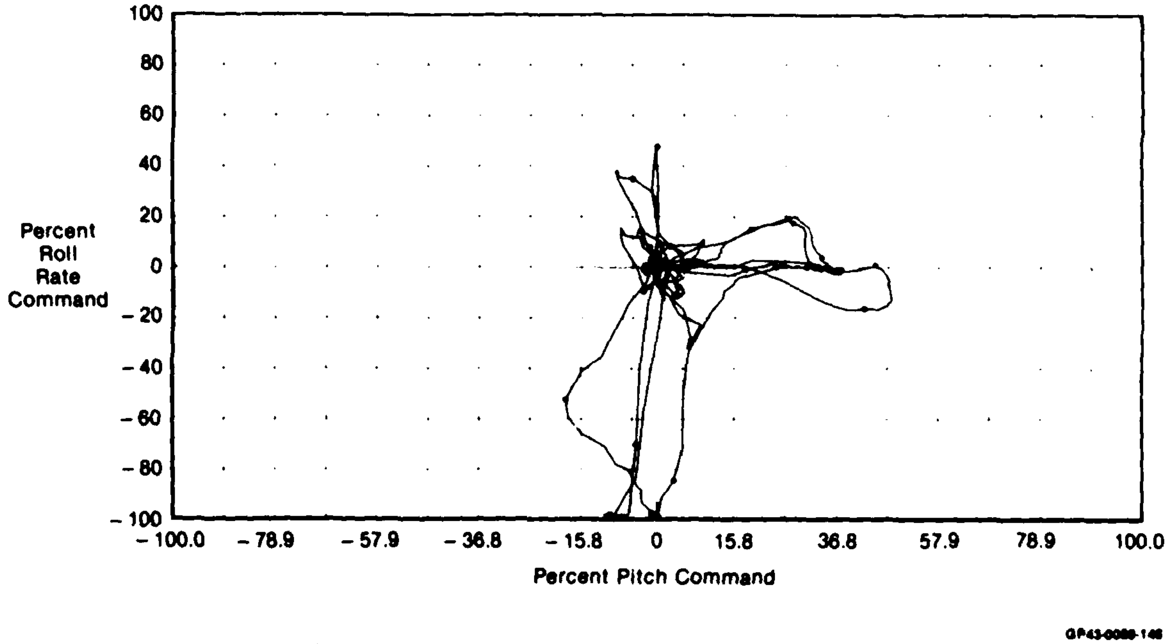

Figure 57. Roll Rate Command vs Pitch Command
Thumb Button Controller   Percent of Maximum

This review of the twist grip and thumb button controller time history data leads to the conclusion that some of the apparent wings level turn-roll rate command coupling could be reduced by modifying the roll rate command deadband. However, if you assume that 15 percent of the roll rate command in Figure 55 is due exclusively to coupling, this leads to a 2.3 pound deadband in the lateral axis. Based on the comments concerning breakout forces found in Ref (70), this amount of deadband may be unacceptable in conventional control. Due to the scope of this effort, no variations in conventional axis deadband were performed. This analysis does point out that the controller designer must consider carefully the interaction of the control axis when uncoupled mode control is added to the conventional flight path controller. It is felt that using a task similar to this and observing cross plots of control inputs along with pilot comments and ratings, the designer could quickly iterate to an optimum simulator configuration in terms of deadbands.

(2) Azimuth Aiming - For the azimuth aiming mode evaluations the pilot rating data indicates clearer trends than those noted for the wings level turn evaluations. This task utilized the three widely spaced targets described in Section 10. The pilot rating data is presented in Figures 58 through 65.

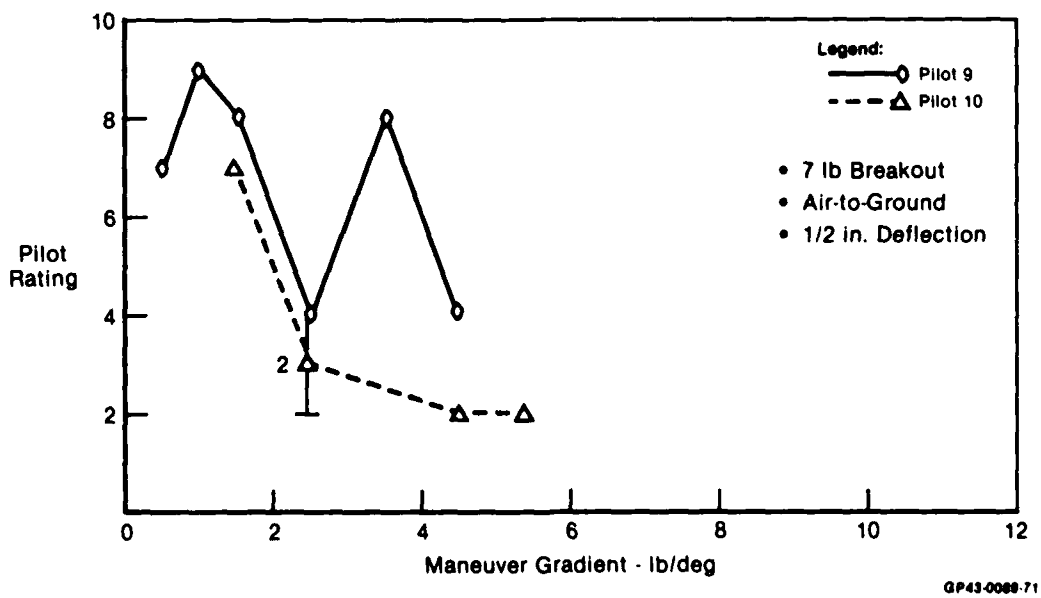

Figure 58. Pilot Rating vs Maneuver Gradient
Rudder Pedals Fuselage Azimuth Aiming

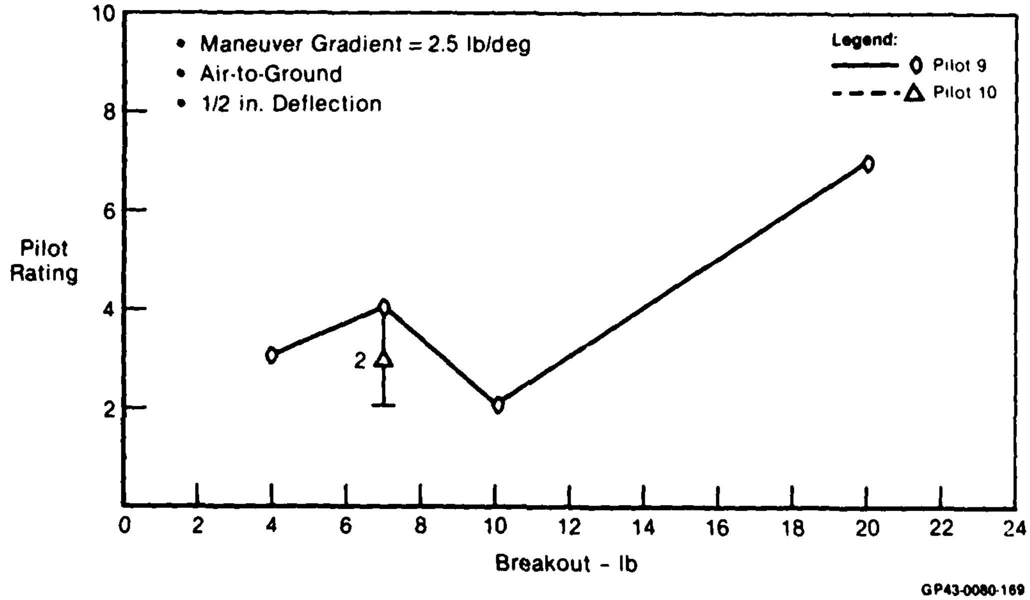

Figure 59. Pilot Rating vs Breakout
Rudder Pedals   Fuselage Azimuth Aiming

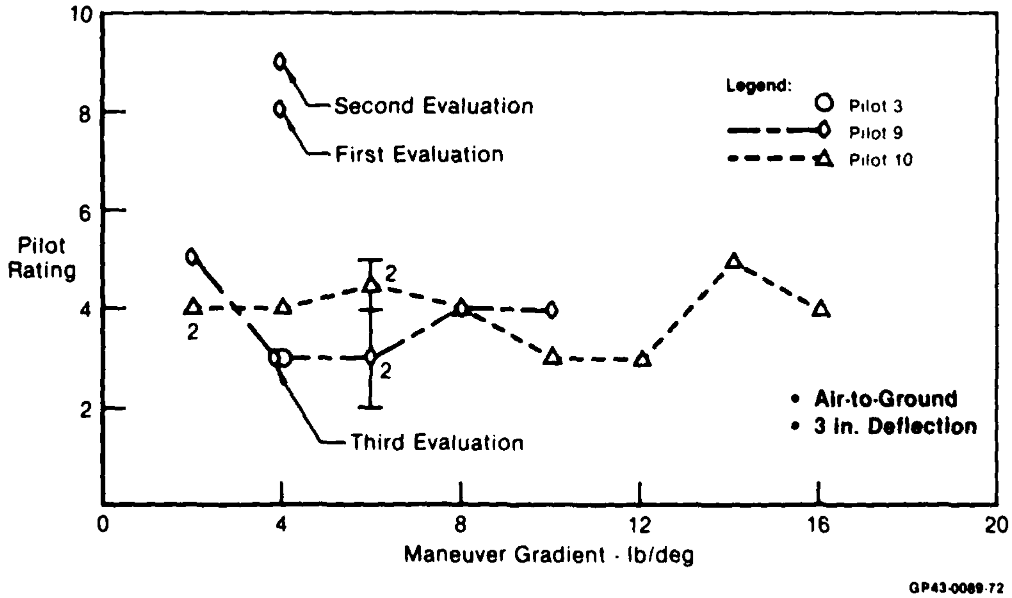

Figure 60. Pilot Rating vs Maneuver Gradient
Rudder Pedals   Fuselage Azimuth Aiming

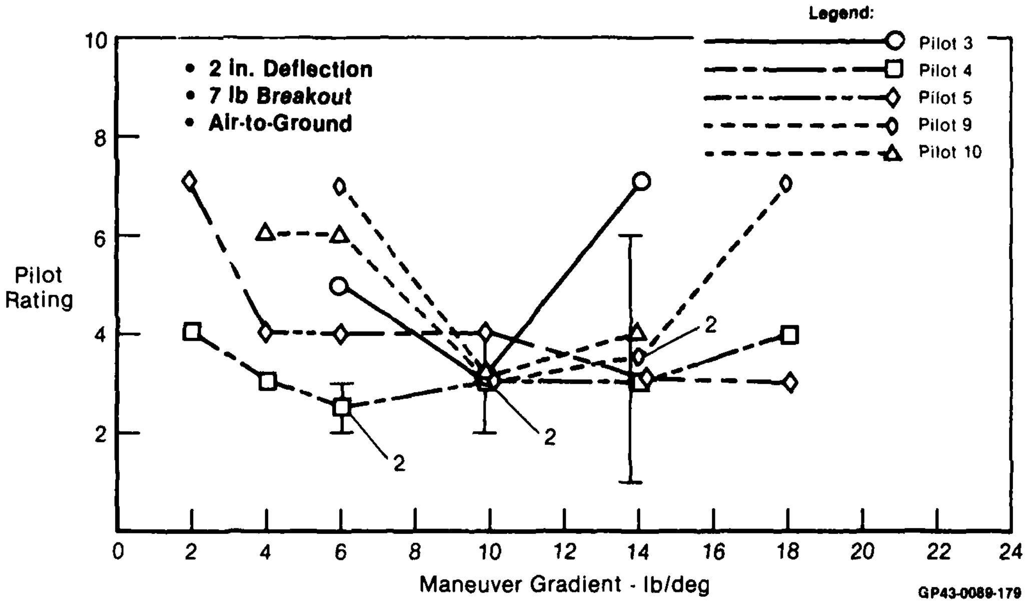

Figure 61. Pilot Rating vs Maneuver Gradient
Rudder Pedals Fuselage Azimuth Aiming

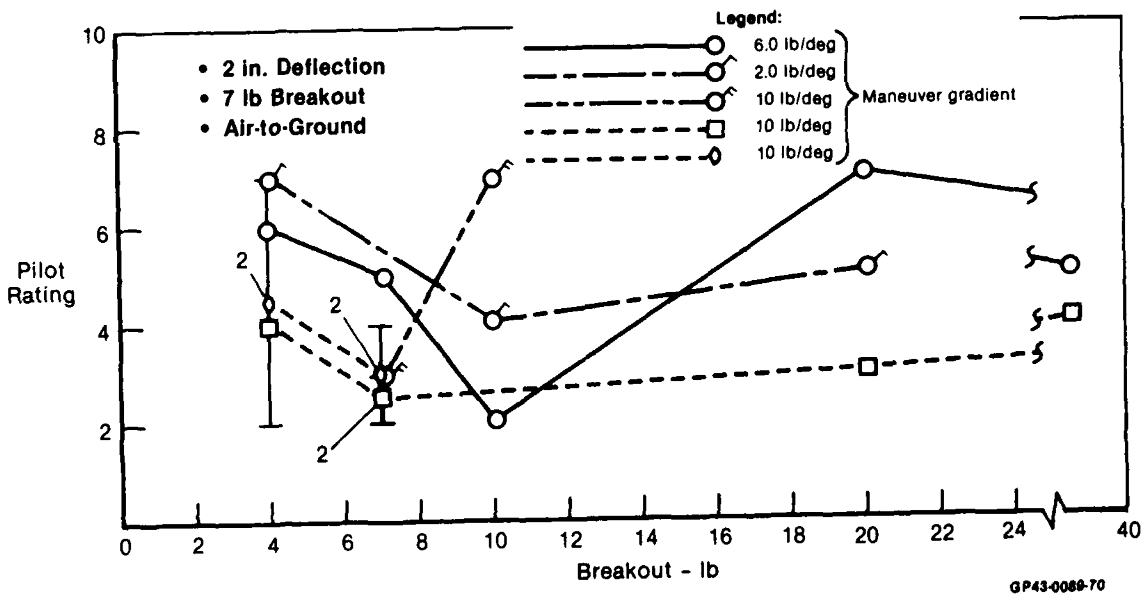

Figure 62. Pilot Rating vs Breakout
Rudder Pedals Fuselage Azimuth Aiming

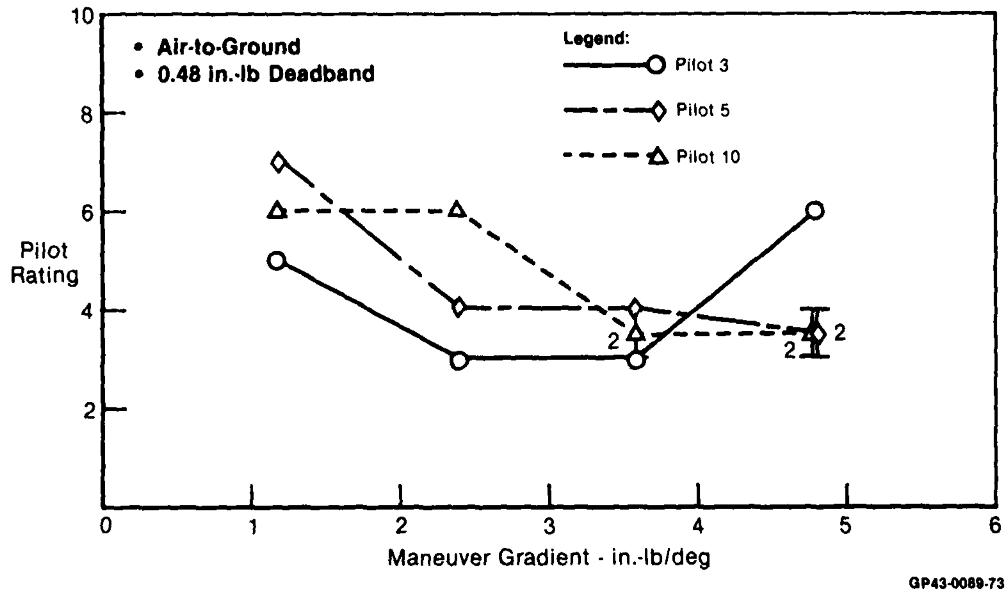

Figure 63. Pilot Rating vs Maneuver Gradient
Twist Grip Sidestick   Fuselage Azimuth Aiming

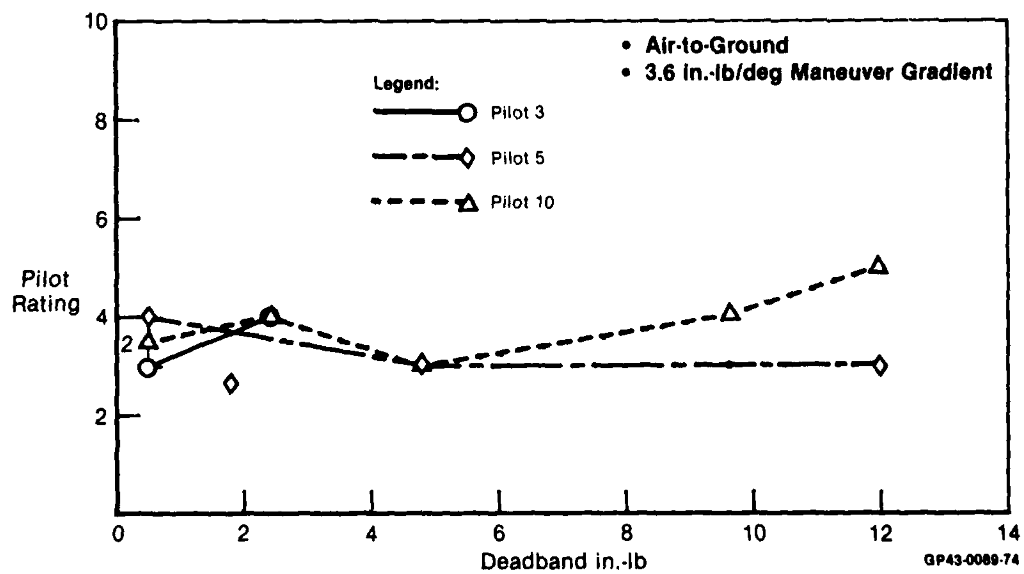

Figure 64. Pilot Rating vs Deadband
Twist Grip Sidestick   Fuselage Azimuth Aiming

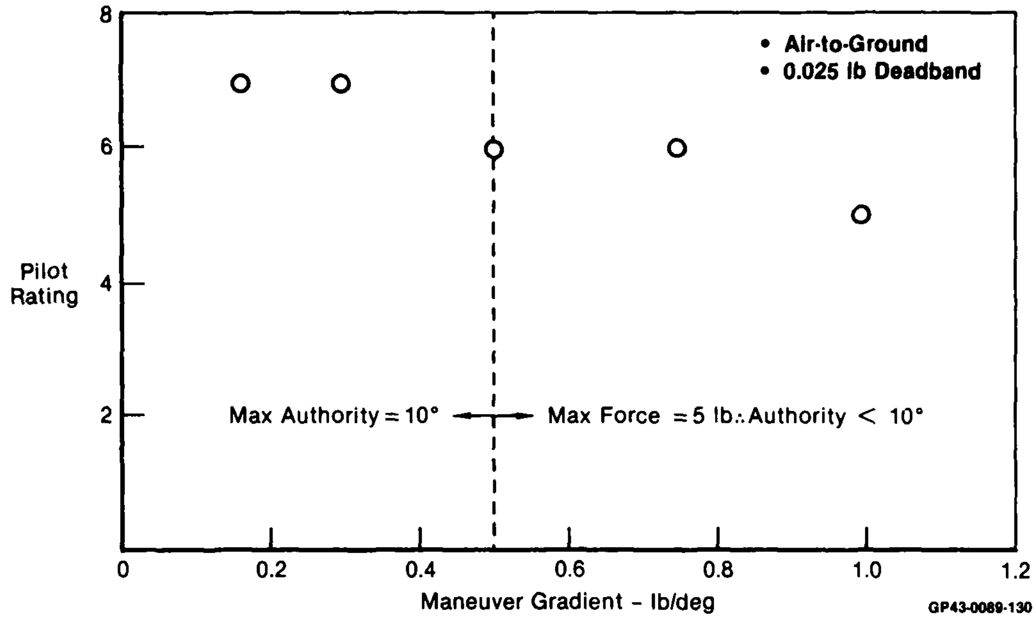

Figure 65. Pilot Rating vs Maneuver Gradient
Thumb Button Controller Fuselage Azimuth Aiming Pilot 10

Two pilots, 9 and 10, evaluated the half inch deflection rudder pedals. Their pilot rating results for the maneuver gradient and breakout variations are shown in Figures 58 and 59. A review of the pilot comments indicated that Pilot 10 liked the short pedal throw while Pilot 9 found that the short throw resulted in predictability and sensitivity problems. Only Pilot 9 evaluated various breakouts using the 2.5 lb/deg maneuver gradient. Pilot 10's ratings for the baseline 7 lb breakout case are also shown. Note the marked degradation in Pilot 9's ratings for the 20 lb breakout force.

The situation was reversed for the 3 inch pedal deflections. The pilot ratings from these evalutions are shown in Figure 60. No breakout variations were conducted for this controller. Pilot 10 disliked the larger throw, commenting on a lack of predictability and what seemed to be a slower response. Pilot 9 did not object to the larger throw, he did however prefer the two inch pedal deflections. Pilot 9's evaluation of the 4 lb per degree maneuver gradient indicates some of the effects of pilot learning. This configuration was the first three inch case examined and he assigned it a CH=8. The 10 lb/deg and 6 lb/deg configurations were examined next and given CH=4 and CH=2 respectively. The 4 lb/deg configuration was then reexamined this time receiving a CH=9.

The next configuration examined had a maneuver gradient of 8.0 lb/deg. The pilot comment that the forces were a little high at the extremes and assigned a CH=4. The pilot was then shown the 4 lb/deg configuration again. This time he assigned a CH=3 commenting that the displacements were fine, the force a little light, he could accomplish the task in a satisfactory manner. It is felt that this configuration probably represents a border-line case where the pilot was finally able to obtain adequate control after several attempts. Insufficient time was available to perform any breakout variations.

The results of the maneuver gradient variation for the two inch pedal deflections are very interesting. It appears that the only universally acceptable configuration was the ten pound per degree gradient. All configurations shown in Figure 61 had a breakout of 7 lbs. The breakout variation results are shown in Figure 62. Note the rapid degradation exhibited by some pilots on either side of the 10 lb/deg gradient. In both the gradient and breakout variation plots, note the wide spread in pilot 9's ratings. At 14 lb/deg the CH=6 was one of Pilot 9's earliest azimuth pointing evaluations. Later the point was repeated and received a CH=1. In the breakout variations notice the range of ratings given by this pilot at the 4 pound level. A CH=2 was given by Pilot 9 on his first evaluation, at a later period he assigned the configuration a CH=7. It should be noted that this rating followed the evaluation of the 14 lb/deg, 7 lb breakout configuration which he gave a CH=1 rating. It is not clear exactly what causes the dispersions in Pilot 9's ratings. One possible reason may be that this pilot is very susceptible to varying his ratings with the order of presentation of the variations.

An interesting trend was noted in the breakout variations for Pilot 3. For this pilot it appears that the influence of breakout variations is highly dependent on the maneuver gradient used. This pilot appears to be more sensitive to breakout as the maneuver gradient is increased. Unfortunately, pilot scheduling problems and a simulator hardware failure prevented further evaluation at the 10 lb/deg maneuver gradient level. Except at the extremes of 4 and 38 lb of breakout, Pilot 4 appears to be insensitive to breakout variations.

The maneuver gradient variations for the twist grip side-stick are shown in Figure 63. The most universally acceptable gradient appears to be at the 3.6 in. lb/deg level. This controller was not as well liked as the rudder pedals. Several cases of pitch and roll coupling were noted using this mode. The reader is referred back to the coupling discussion in the wings level turn evaluations for a detailed examination of this phenomenon.

The deadband variations on the twist grip sidestick are illustrated in Figure 64. Pilot 5 appears to be insensitive to deadband variations at the 3.6 in-lb/deg maneuver gradient level. Pilot 10 shows some sensitivity to increases in deadband above the 4.8 in-lb level. At the lowest deadband level all pilots exhibited coupling of roll inputs into the twist axis when performing the pop-up maneuver.

Pilot 10 attempted to evaluate the thumb button controller for use with the azimuth pointing mode. These results are presented in Figure 65. As indicated, no acceptable maneuver gradient could be found which had enough authority to accomplish the full task. It is estimated that an acceptable gradient may occur somewhere beyond the one pound per degree level. These results are easily understood if the reader recalls the pilot techniques adopted by Pilot 6 in the wings level turn evaluation. Pilot 6 indicated that the best use of the button was as an on-off type controller. This technique cannot be used with the proportional pointing command during the azimuth aiming tasks since it requires continuous commands. Based on these results, attempts to control the azimuth aiming mode with this controller were abandoned.

b. Approach and Landing - During this phase the wings level turn, fuselage azimuth aiming and lateral translation modes were used to augment lateral-directional aircraft control. A limited number of runs were used to collect pilot comments using the vertical translation mode for direct flight path control. As described in Section 10, the task was a STOL fighter approach focusing on precision touchdown point control in the presence of atmospheric disturbances.

For the wings level turn mode four controllers were evaluated: rudder pedals, a twist grip on the pilot's sidestick controller, a thumb button controller mounted on the top center of the sidestick, and a thumbwheel mounted on a grip to be used by the pilot's left hand. The rudder pedals and the twist grip controller were evaluated for use with the lateral translation mode. For the fuselage azimuth aiming mode, the rudder pedals, twist grip, and thumb controller were evaluated.

(1) Wings Level Turn - The pilots had 0.2g of wings level turn authority available during the approach. Examination of the pilot ratings of Figures 66, 67 and 68 indicate a preference for rudder pedal maneuver gradients below the 300 pounds per "g" level with the optimum appearing to be between 100 and 200 lb/g. Additionally, Figure 66 indicates that one pilot did not like gradients below 75 pounds per "g" with the half inch maximum pedal deflection. No clear preference was indicated for the half inch, two inch or three inch pedal deflection. The data of Figures 69 and 70 generally show degradation in pilot rating for rudder pedal breakout forces above 7 pounds. A minimum acceptable breakout force was not observed.

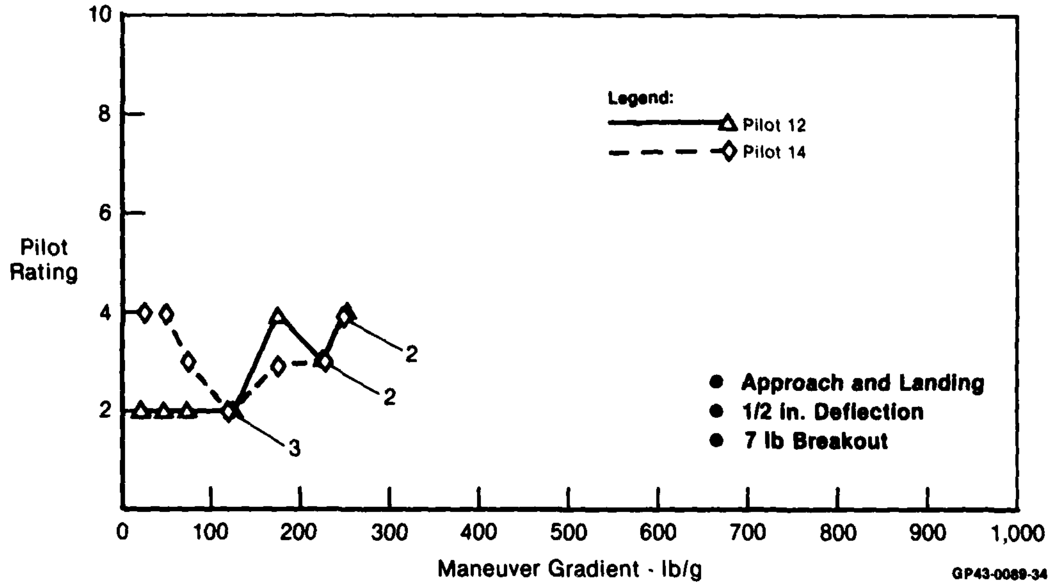

Figure 66. Pilot Rating vs Maneuver Gradient
Rudder Pedals   Wings Level Turn

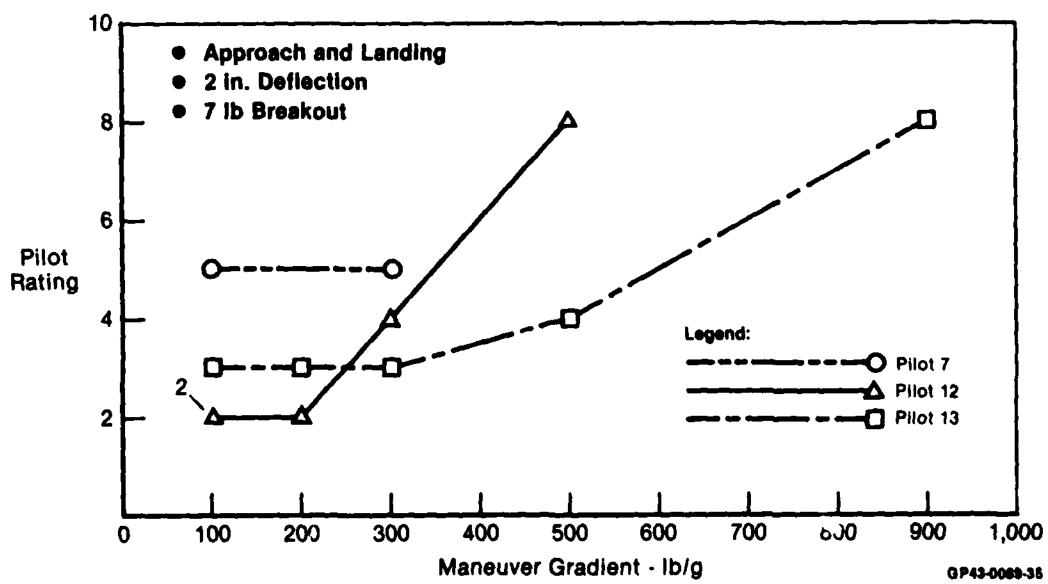

Figure 67. Pilot Rating vs Maneuver Gradient
Rudder Pedals   Wings Level Turn

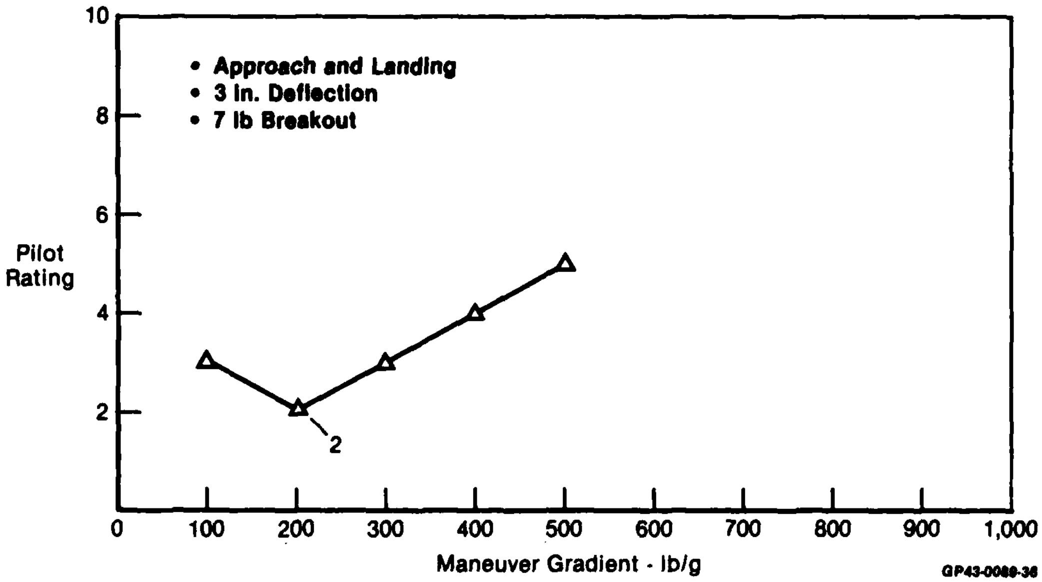

Figure 68. Pilot Rating vs Maneuver Gradient
Rudder Pedals Wings Level Turn Pilot 12

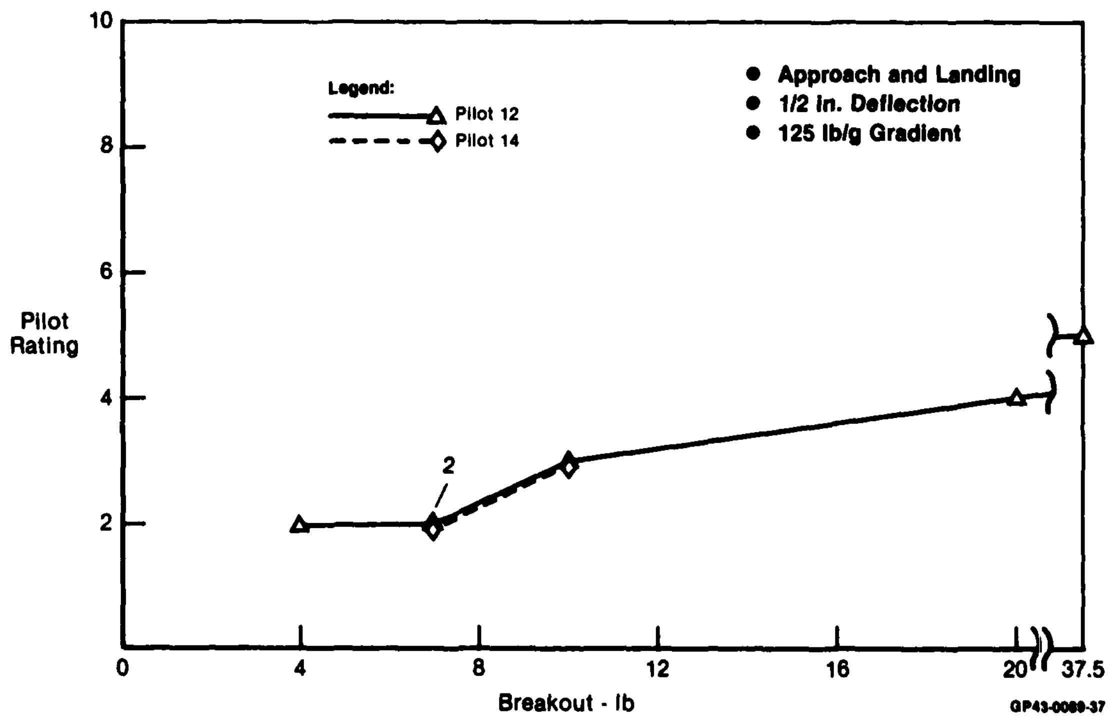

Figure 69. Pilot Rating vs Breakout
Rudder Pedals Wings Level Turn

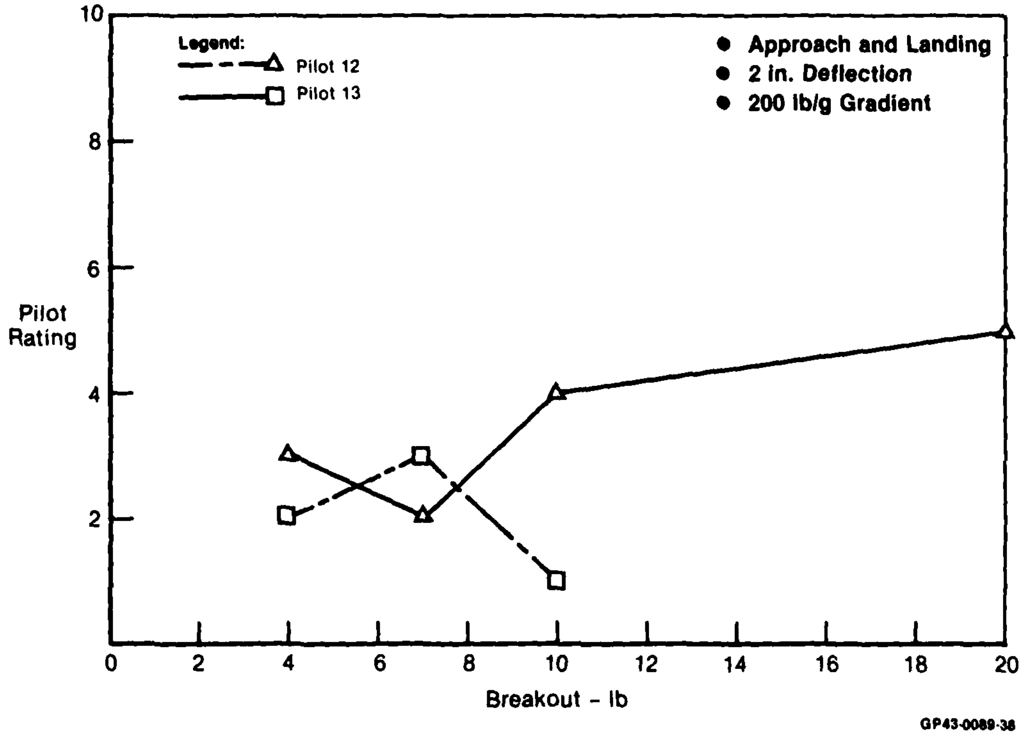

Figure 70. Pilot Rating vs Breakout
Rudder Pedals   Wings Level Turn

A review of Figures 71 and 72 indicates no strong opinion on maneuver gradient or deadband for the twist grip-wings level turn combination. Pilot 12 did indicate a preference for the lower maneuver gradients. This preference was also indicated by the comments of Pilot 13, though it is not apparent in his ratings. Pilot 12 was not comfortable with the twist grip controller in any of the evaluations.

The thumb controller-wings level turn pilot ratings of Figures 73 and 74 indicate some preference by Pilot 12 for the lower maneuver gradients and breakouts. It is interesting to note that at the 5 pound per "g" gradient, a one pound force applied by the pilot results in full command. Couple this with the fact that a .75 lb deadband resulted in a pilot rating of "4" may indicate that the pilot is not executing fine control inputs. Instead there may be a tendency to use on-off type control inputs. Review of the pilot comments indicated this on-off control strategy was used with the more sensitive grip and thumb controller configurations.

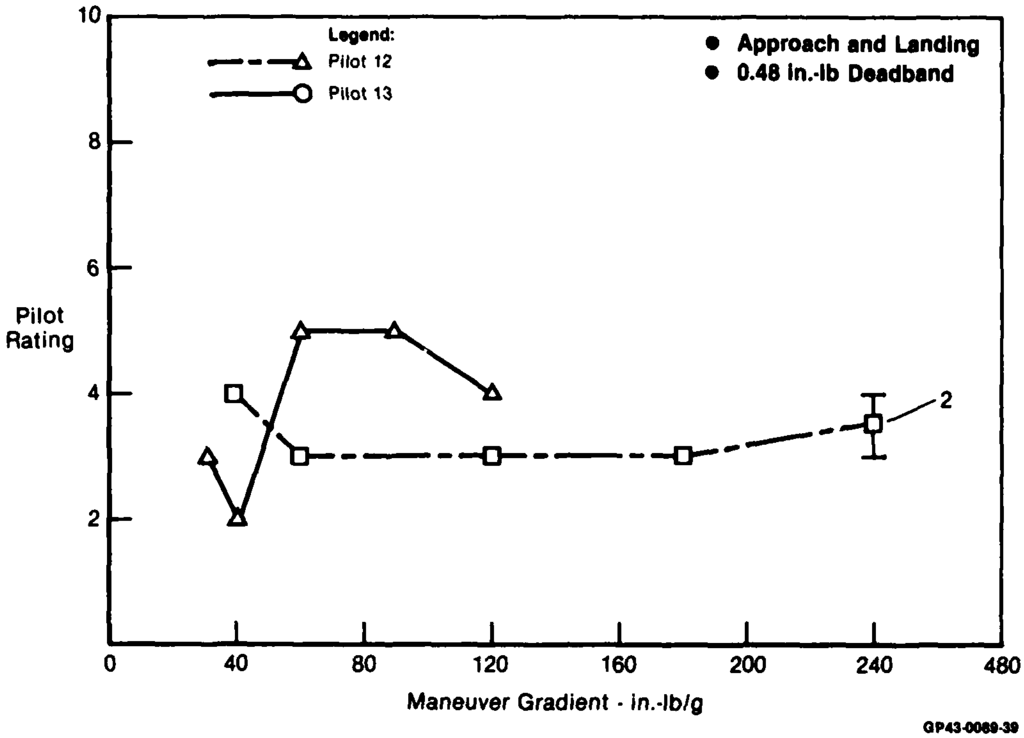

Figure 71. Pilot Ratings vs Maneuver Gradient
Twist Grip Sidestick   Wings Level Turn

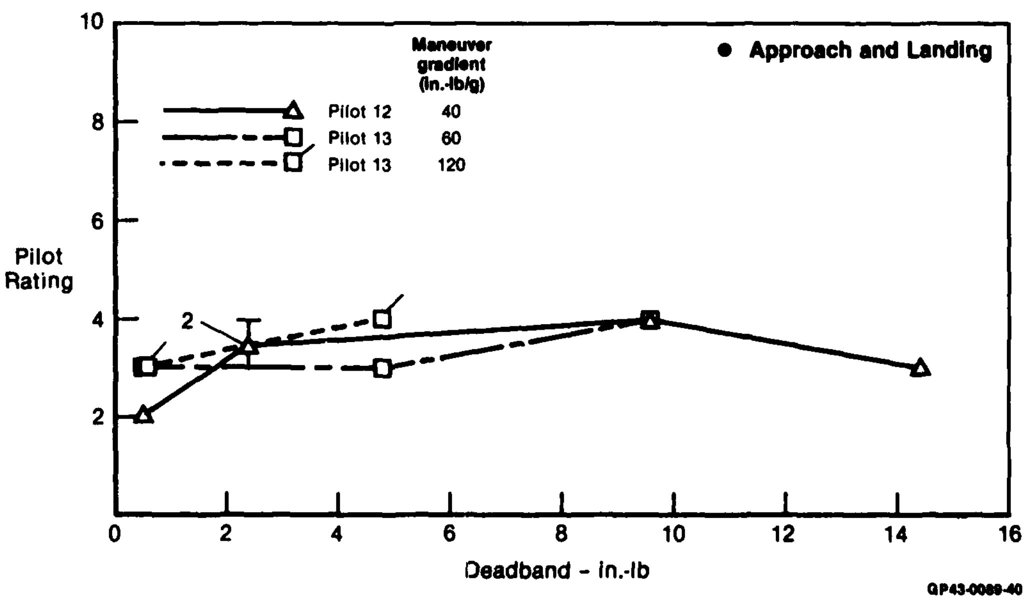

Figure 72. Pilot Rating vs Deadband
Twist Grip Sidestick   Wings Level Turn

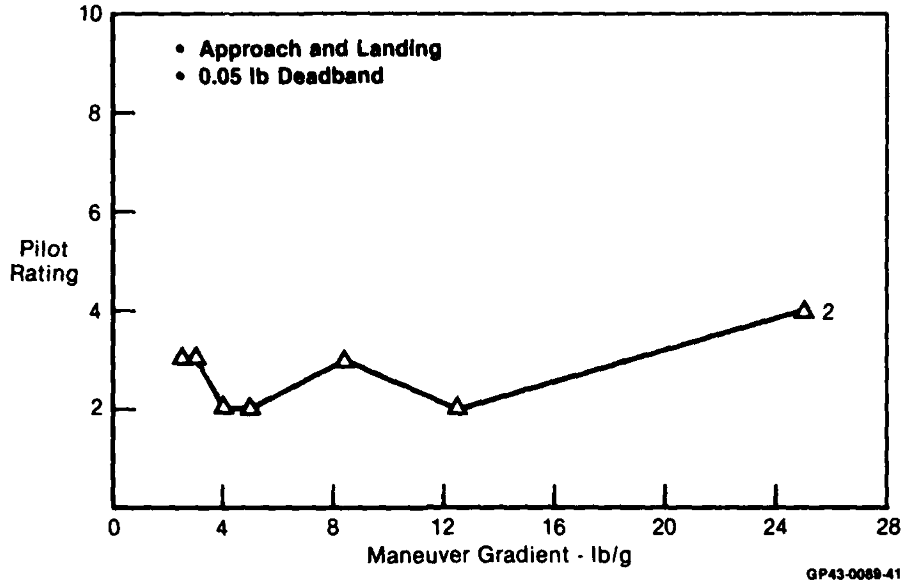

Figure 73. Pilot Rating vs Maneuver Gradient
Thumb Button Controller Wings Level Turn Pilot 12

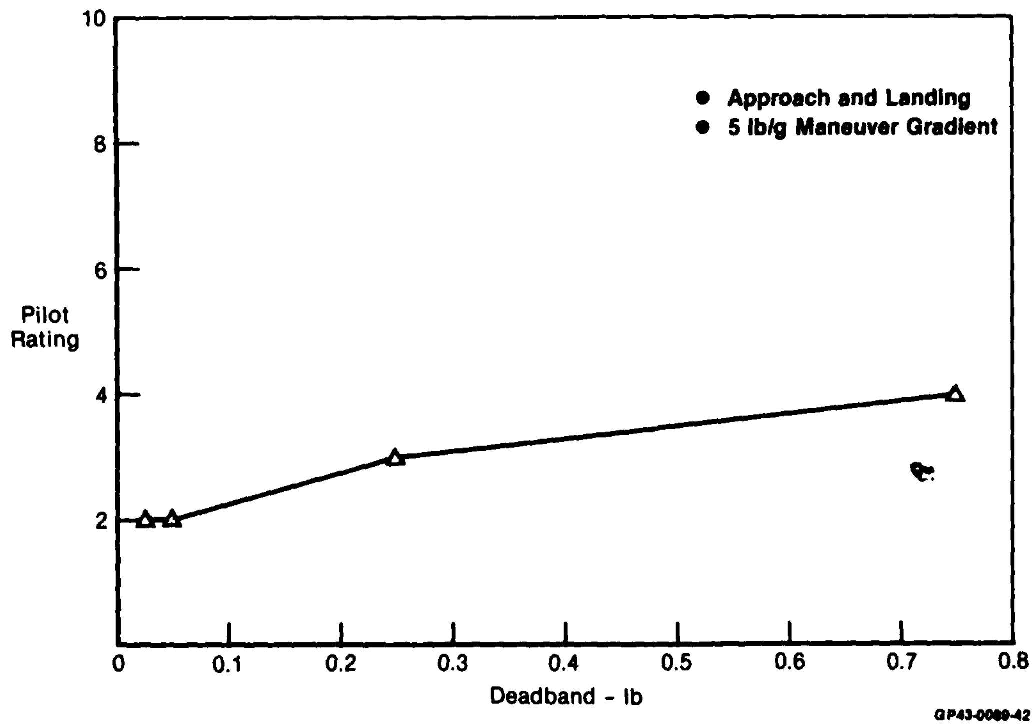

Figure 74. Pilot Rating vs Deadband
Thumb Button Controller Wings Level Turn Pilot 12

Both pilots 12 and 14 were involved in a limited evaluation of a left hand operated thumbwheel controller commanding wings level turn. Unfortunately, as previously discussed, the exact mechanical characteristics of this controller are unavailable. The only controller variations examined were maneuver gradient changes. Both pilots responded well to this controller. They indicated that the thumbwheel would be their second choice for preferred controller. The rudder pedals were their first choice.

(2) <u>Lateral Translation</u> - Pilot comments indicate that the lateral translation mode was confusing and not well liked by either of the evaluation pilots. These comments are apparent in the pilot rating data shown in Figures 75, 76 and 77. Due to these problems, it is felt that no useful trends or recommendations can be derived from these plots or the pilot comments in terms of controller requirements.

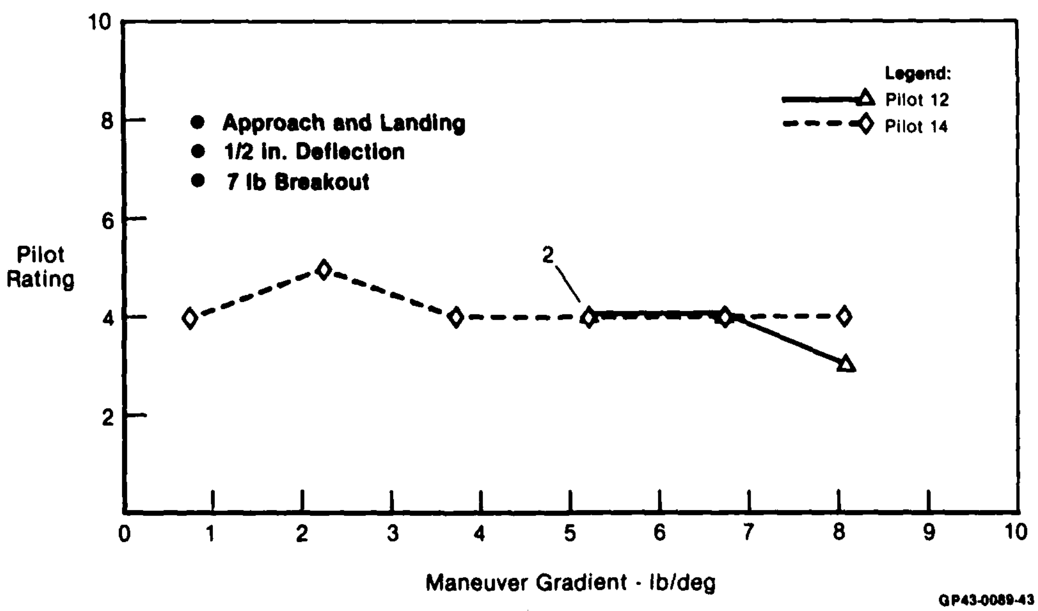

Figure 75. Pilot Rating vs Maneuver Gradient
Rudder Pedals Lateral Translation

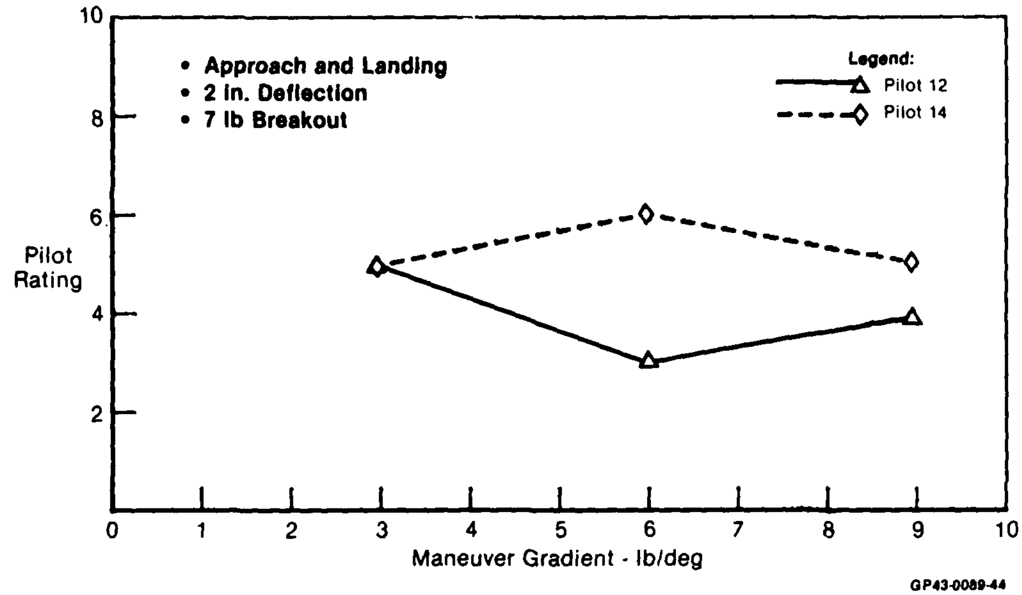

Figure 76. Pilot Rating vs Maneuver Gradient
Rudder Pedals   Lateral Translation

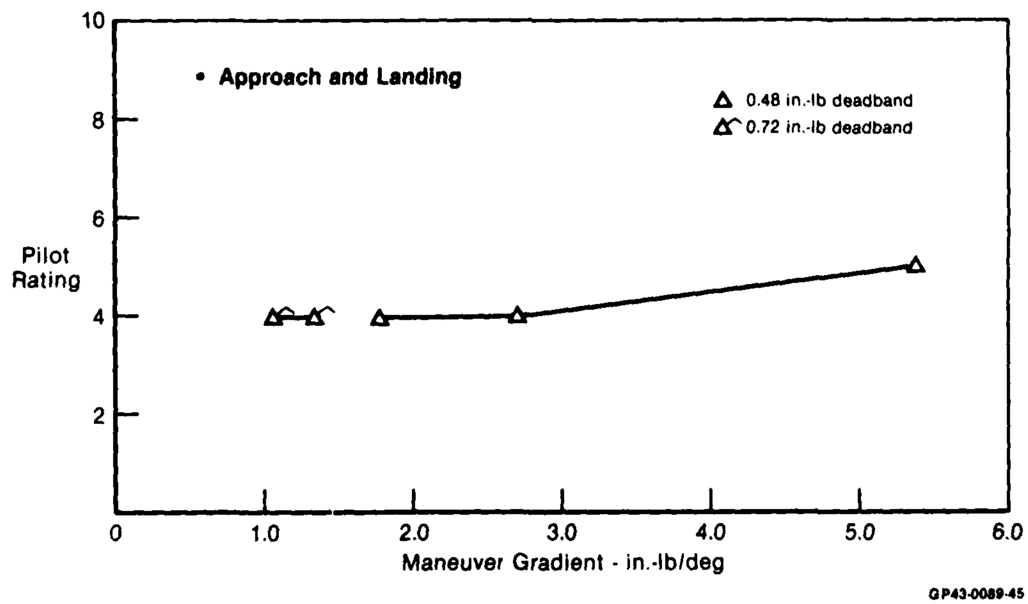

Figure 77. Pilot Rating vs Maneuver Gradient
Twist Grip Sidestick   Lateral Translation   Pilot 12

(3) Fuselage Azimuth Aiming - The fuselage azimuth aiming results are shown in Figures 78 and 79. The mode was used to maintain fuselage orientation down the runway despite the cross wind corrections necessary due to wind shear. This significantly reduced or eliminated the large crab angles at touchdown that were evident during the wings level turn evaluations. With the two inch deflection pedals (Figure 78), satisfactory pilot ratings were obtained over the range from 2 to 6 pounds per degree (recall the previous discussion of Pilot 7's limited evaluation). All configurations had 10° of authority. Pilot 14 indicated dissatisfaction with the half inch pedal deflection. He indicated a general loss in precision of his control inputs. Pilot 12 looked at using the twist grip with this mode. The resulting poor ratings are due to the inability to control the conventional response during landing while also holding in a twist command. No acceptable ratings were collected during this evaluation.

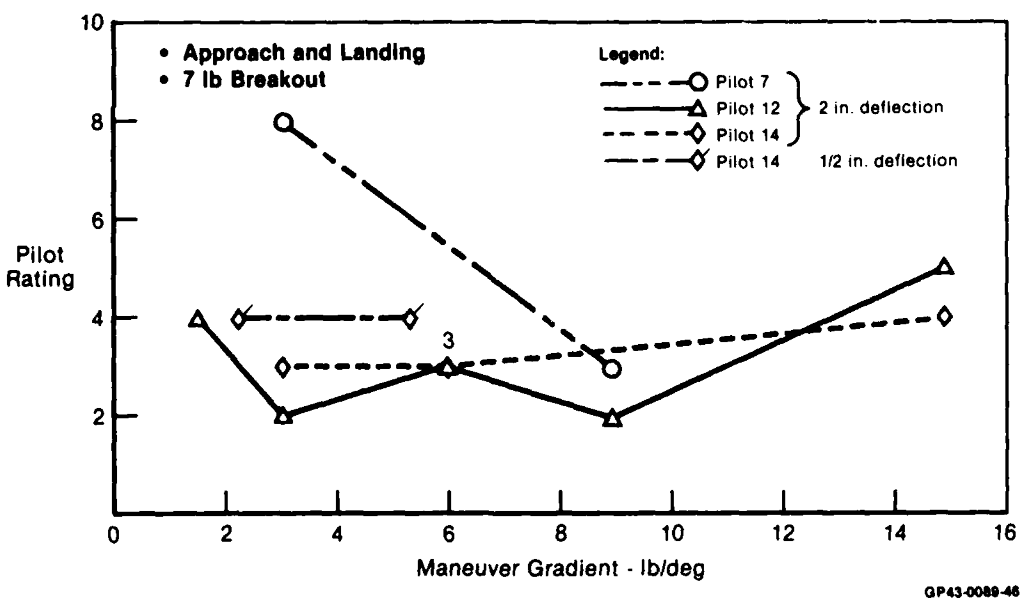

Figure 78. Pilot Rating vs Maneuver Gradient
Rudder Pedals Fuselage Azimuth Aiming

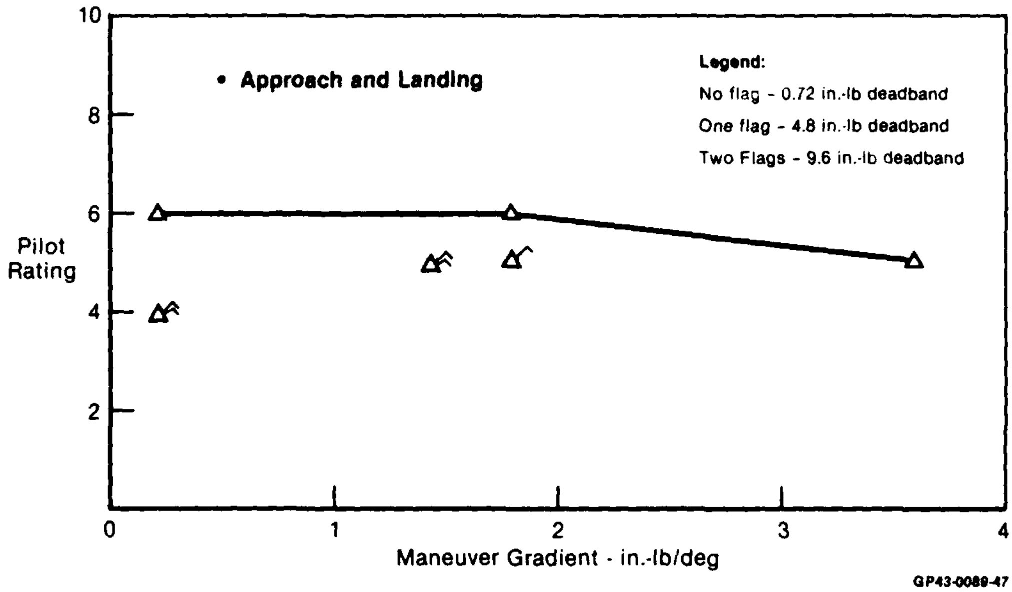

Figure 79. Pilot Rating vs Maneuver Gradient
Twist Grip Sidestick   Fuselage Azimuth Aiming   Pilot 12

(4) Vertical Translation - A limited evaluation of vertical translation for flight path control was conducted. The mode was primarily used immediately prior to touchdown. Pilot 12 would use the mode to control the touchdown point. He found that he could reduce his descent rate using conventional controls to flare and then apply down translation commands to "plant" the airplane on the desired touchdown point. Pilot 13 used the mode to control sink rate. He would establish himself on the glide slope aimed at the touchdown point. Just prior to touchdown he would apply up translation to decrease his sink rate while holding the conventional controls fixed. Both pilots evaluated the AFTI/F-16 type twist grip throttle and the heave axis on the 4-axis controller. The twist throttle was the preferred controller. Pilot 12 in particular complained of coupling between conventional pitch inputs and heave inputs, especially during flare.

(5) Comments on Approach and Landing Results - Regardless of mode examined, the pilots indicated a preference for the rudder pedals as a lateral-directional uncoupled controller. The thumbwheel was second followed by the twist grip and thumb button.

The results of combinations using rudder pedals, thumbwheel, and twist throttle are interesting when viewed overall. In all cases these controllers were favored over controllers mounted on the pilot's conventional aircraft controller. This may indicate that the pilots prefer delegation of additional control responsibilities to controllers separate from those used for conventional control in this task.

AD-A153 300 CONTROLLER REQUIREMENTS FOR UNCOUPLED AIRCRAFT MOTION 2/6
VOLUME 2(U) MCDONNELL AIRCRAFT CO ST LOUIS MO
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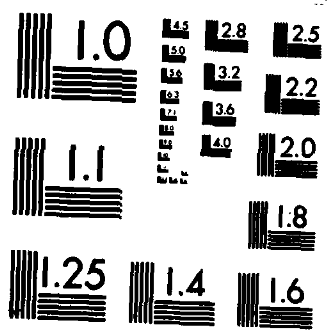


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

c. Air-to-Air Tracking - The analysis of the pilot rating data from the air-to-ground and landing tasks exhibited little variation in pilot ratings over a broad range of breakouts and deadbands. Both of these tasks were operationally oriented. The air-to-ground portion concentrated on dynamic tasks against multiple targets while the approach and landing tasks were visual. These tasks exhibit little variation in pilot ratings over a broad range of breakouts and deadbands. It was felt that the use of a continuous fine tracking task should highlight any pilot sensitivity to variations in these parameters.

As described in Section 10, air-to-air fine tracking tasks were used exclusively. Two target maneuvers were utilized. One involved nearly constant altitude, moderate amplitude target roll motion about a zero mean bank angle. This target will henceforth be referred to as a level target. The other target type involved small roll perturbations about a level 2g turn and will be referred to as a turning target.

Three pilots participated in the air-to-air evaluations. Due to a hardware failure in the motion drive system, the evaluations were divided into two periods with two pilots participating in each phase. These pilots will be identified as Pilots 21, 22, and 23. All three had participated in the air-to-ground simulation; however, one had used only the azimuth aiming mode. The failure of the motion drive system resulted in comparison of ratings for Pilots 21 and 22 with and without motion. In addition, during the second phase of the evaluations, Pilot 22 duplicated his earlier evaluations in the presence of turbulence and motion system disturbance. Sub-section (d) will address these comparisons as well as the comparison of Pilot 23's air-to-air and air-to-ground Cooper-Harper ratings. In the present section we will discuss only the evaluations with the motion system on and with no turbulence.

The rudder pedals, twist grip sidestick, and thumb button controllers were examined in the air-to-air tasks. The discussions will center on the pilot rating results and the pipper error dispersion data collected during the simulation. A complete discussion of the tasks and procedures used was previously presented in subsection 10.

(1) Wings Level Turn - Figures 80 through 89 compare Pilot 23's Cooper-Harper ratings with those gathered in the first air-to-air simulation by Pilots 21 and 22. Pilot 23 was physically the largest participating pilot and probably represents an extreme in terms of height that would be encountered in service pilots. While he did not complain of any cockpit interference problems, his seating position relative to the controllers was significantly different than the other pilots. In particular, Pilot 23 commented that due to the position of the rudder pedals,

even at maximum adjustment, he was forced to move his whole leg in making pedal inputs. Pilots 21 and 22 had commented that the best use of the pedals was by depressing them using only their toes where possible. This offered significantly finer control but may also have increased their sensitivity to breakout forces and higher levels of maneuver gradient.

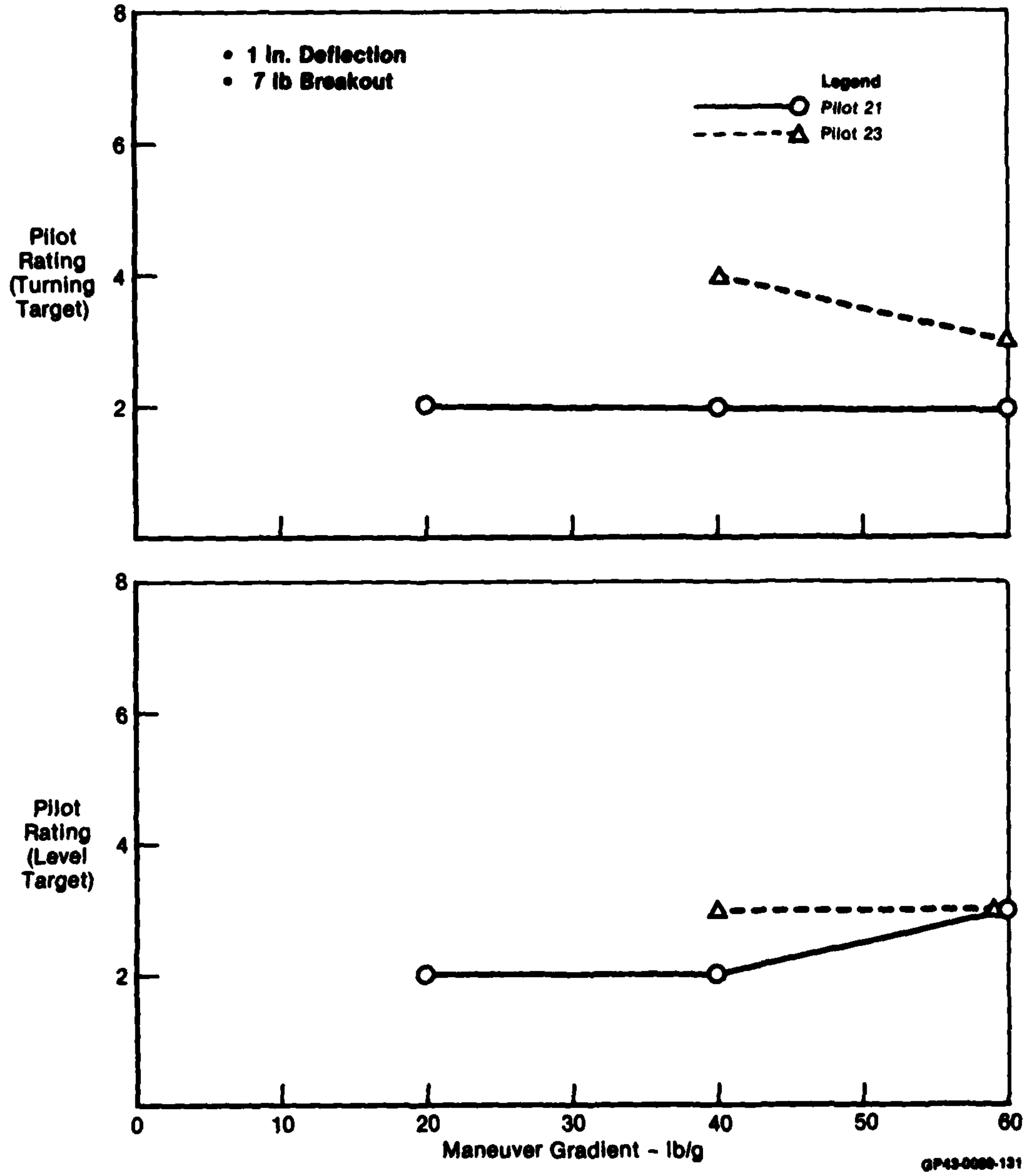


Figure 80. Pilot Rating vs Maneuver Gradient
Rudder Pedals Wings Level Turn

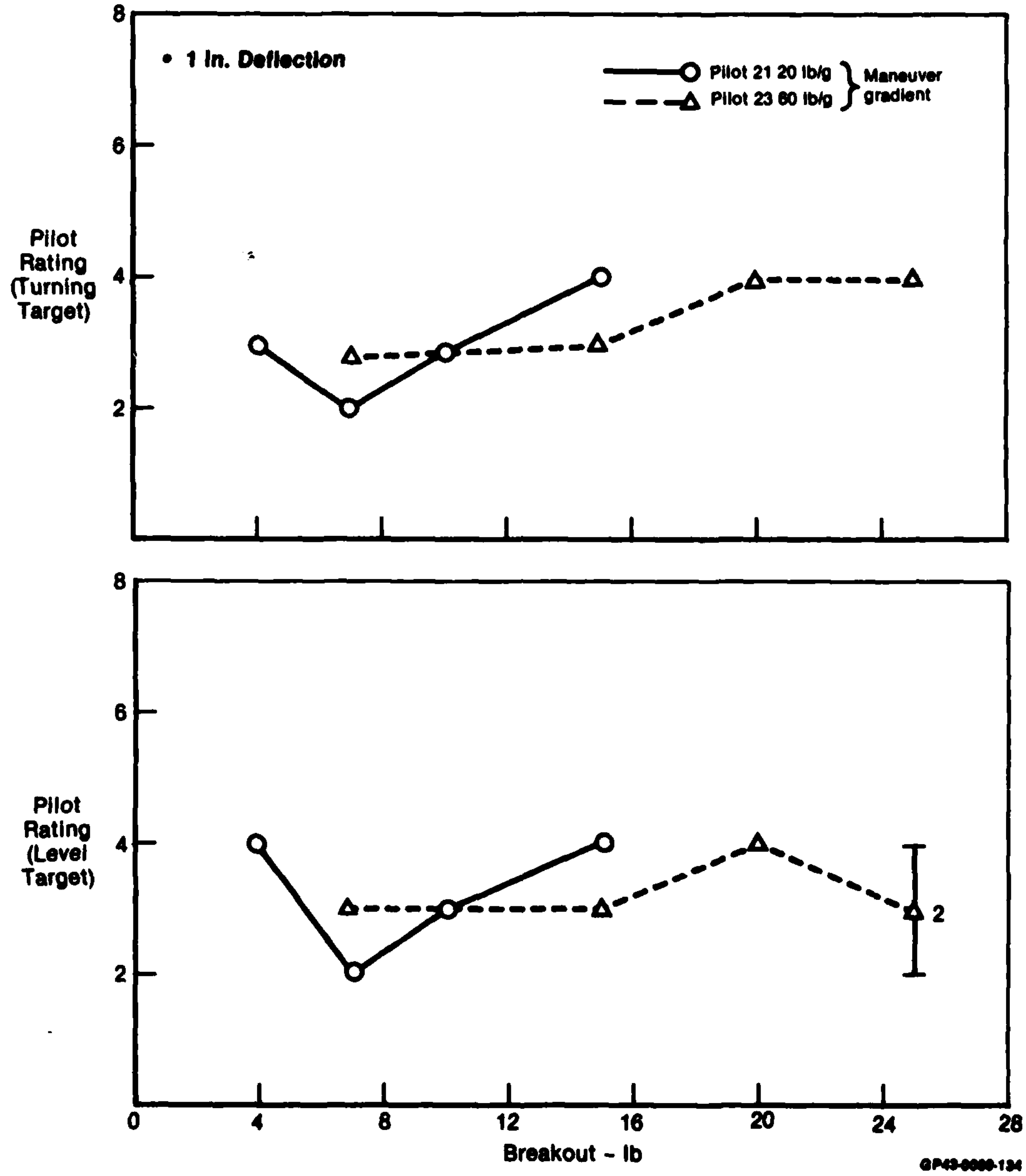


Figure 81. Pilot Rating vs Breakout
Rudder Pedals Wings Level Turn

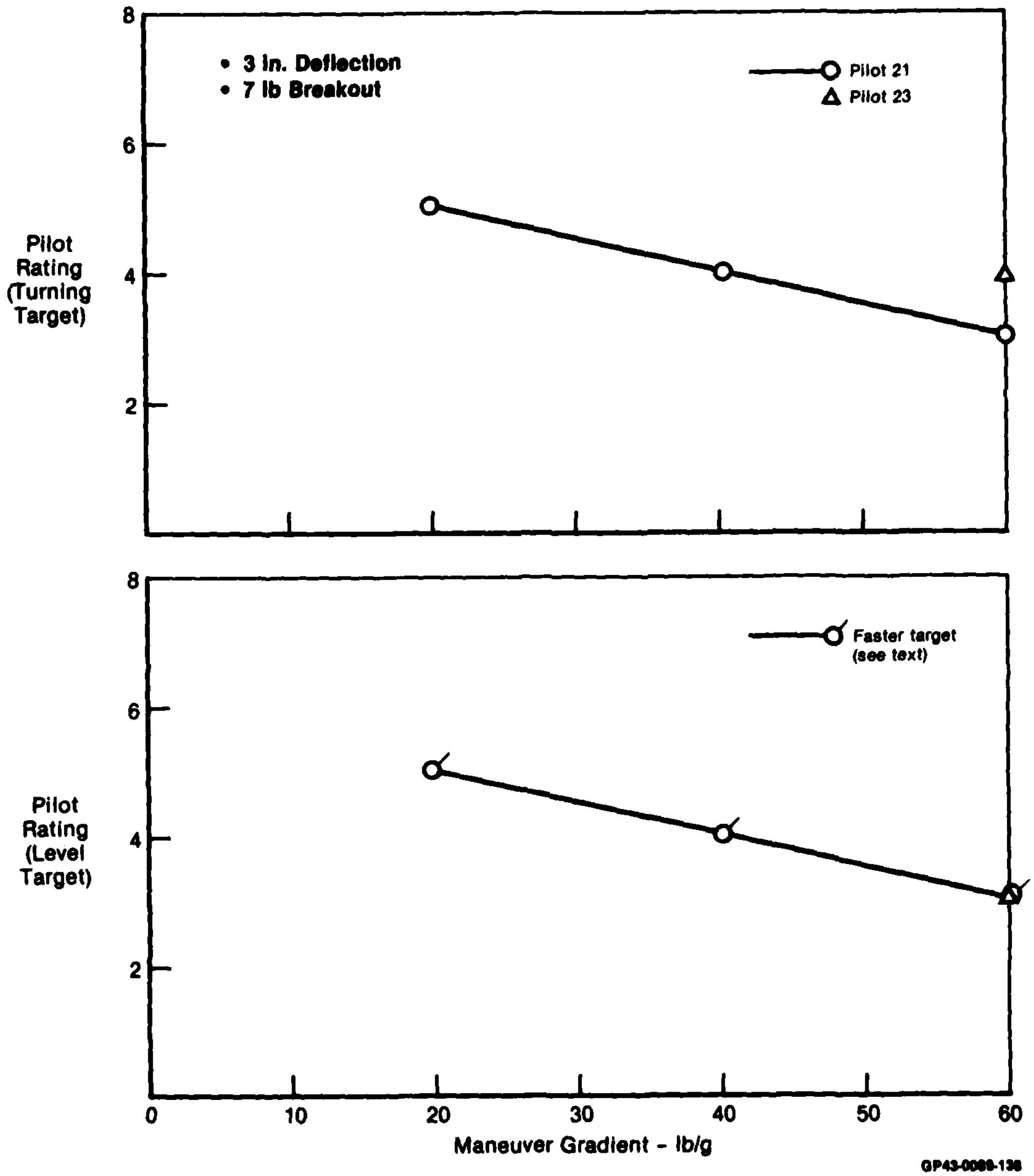


Figure 82. Pilot Rating vs Maneuver Gradient
Rudder Pedals Wings Level Turn

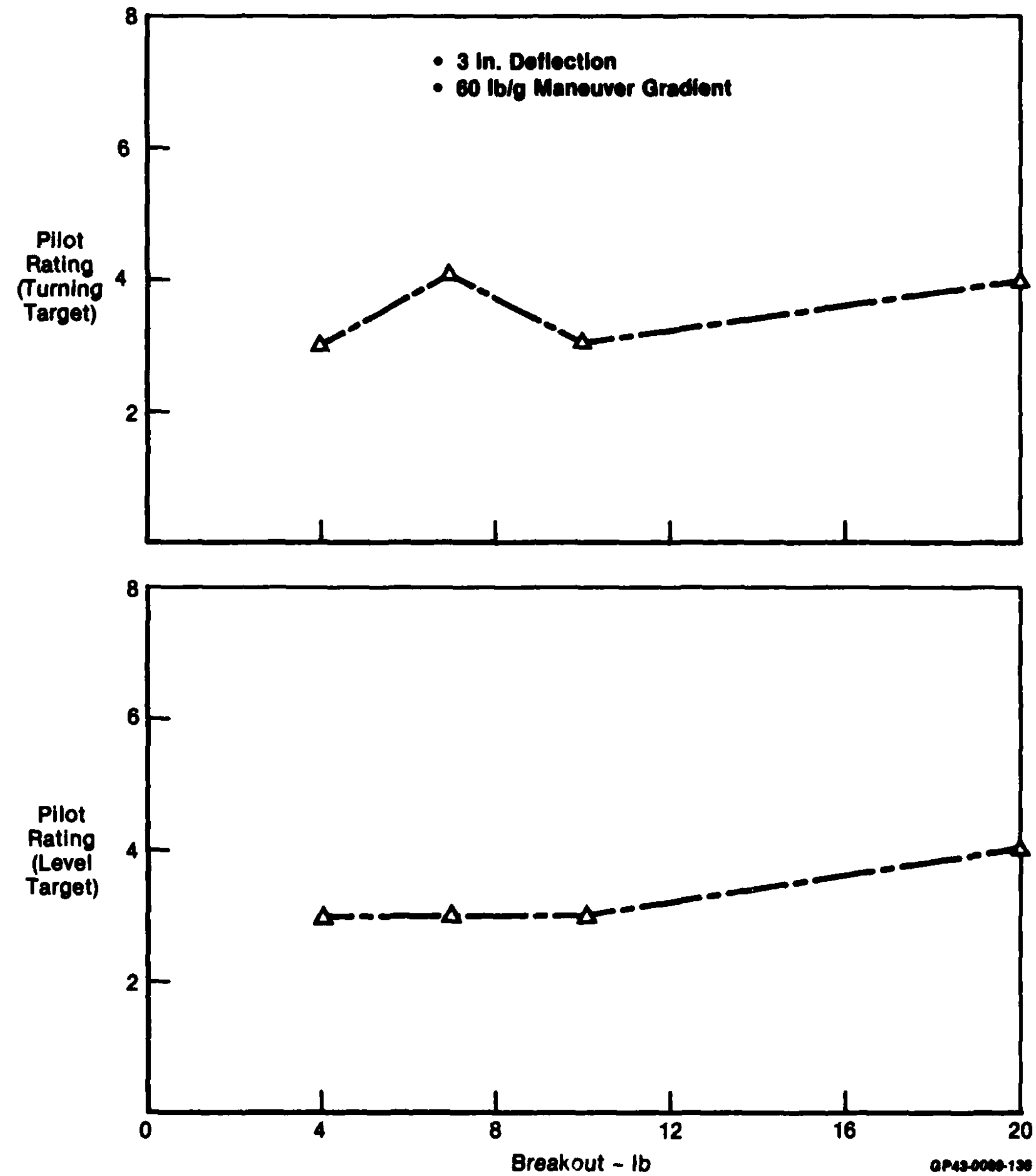


Figure 83. Pilot Rating vs Breakout
Rudder Pedals Wings Level Turn Pilot 23

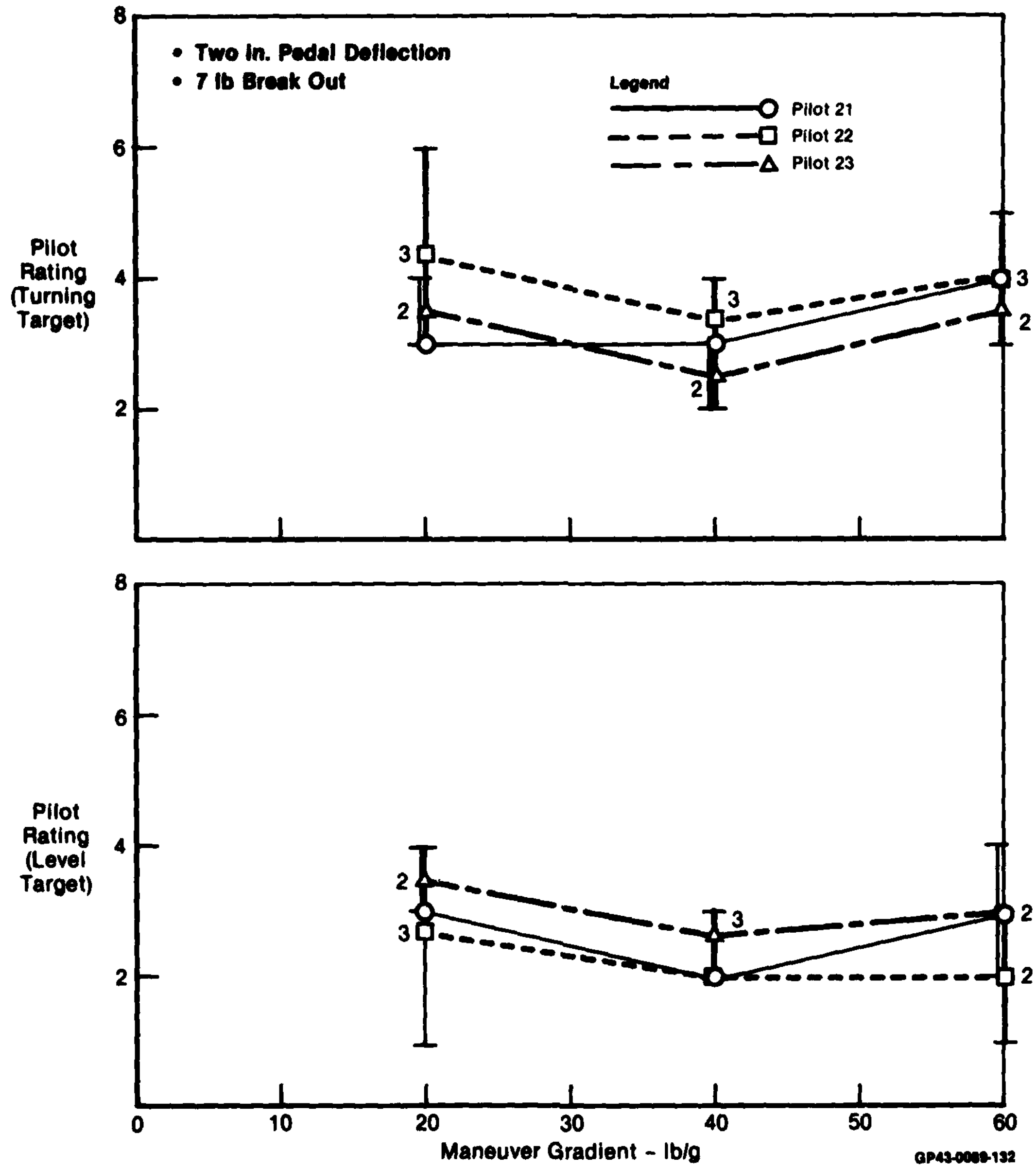


Figure 84. Pilot Rating vs Maneuver Gradient
Rudder Pedals Wings Level Turn

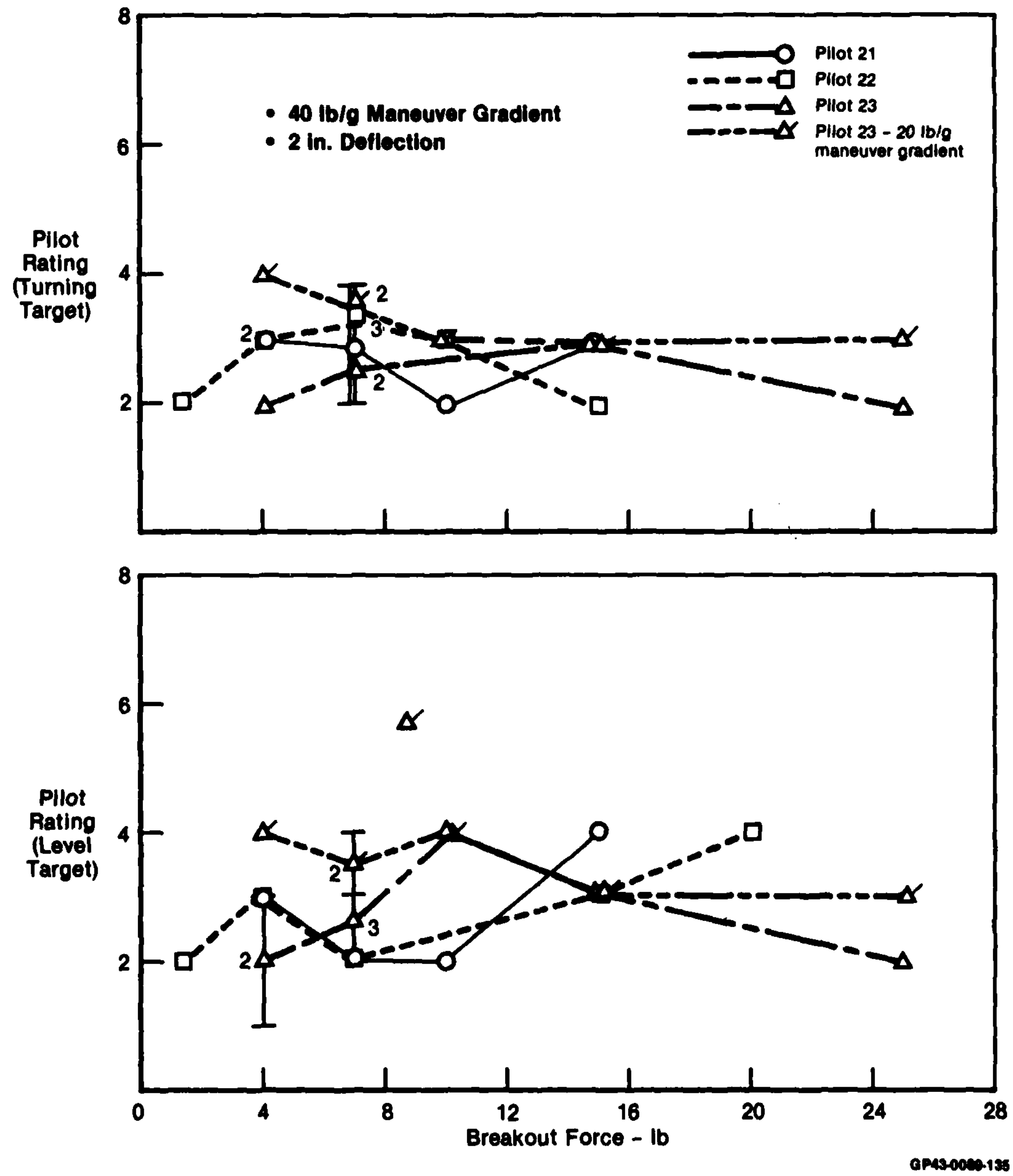


Figure 85. Pilot Rating vs Breakout Force
Rudder Pedals Wings Level Turn

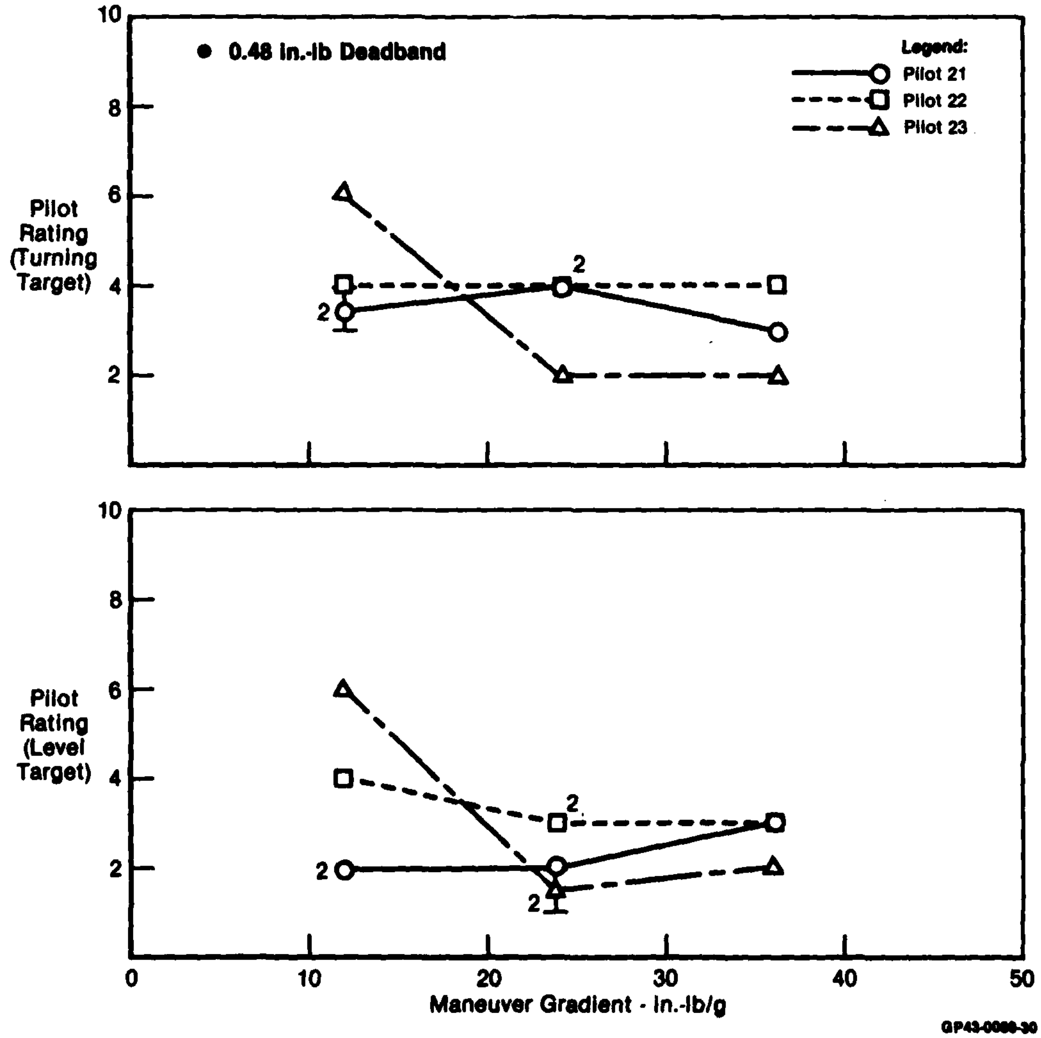


Figure 86. Pilot Rating vs Maneuver Gradient
Twist Grip Sidestick Wings Level Turn

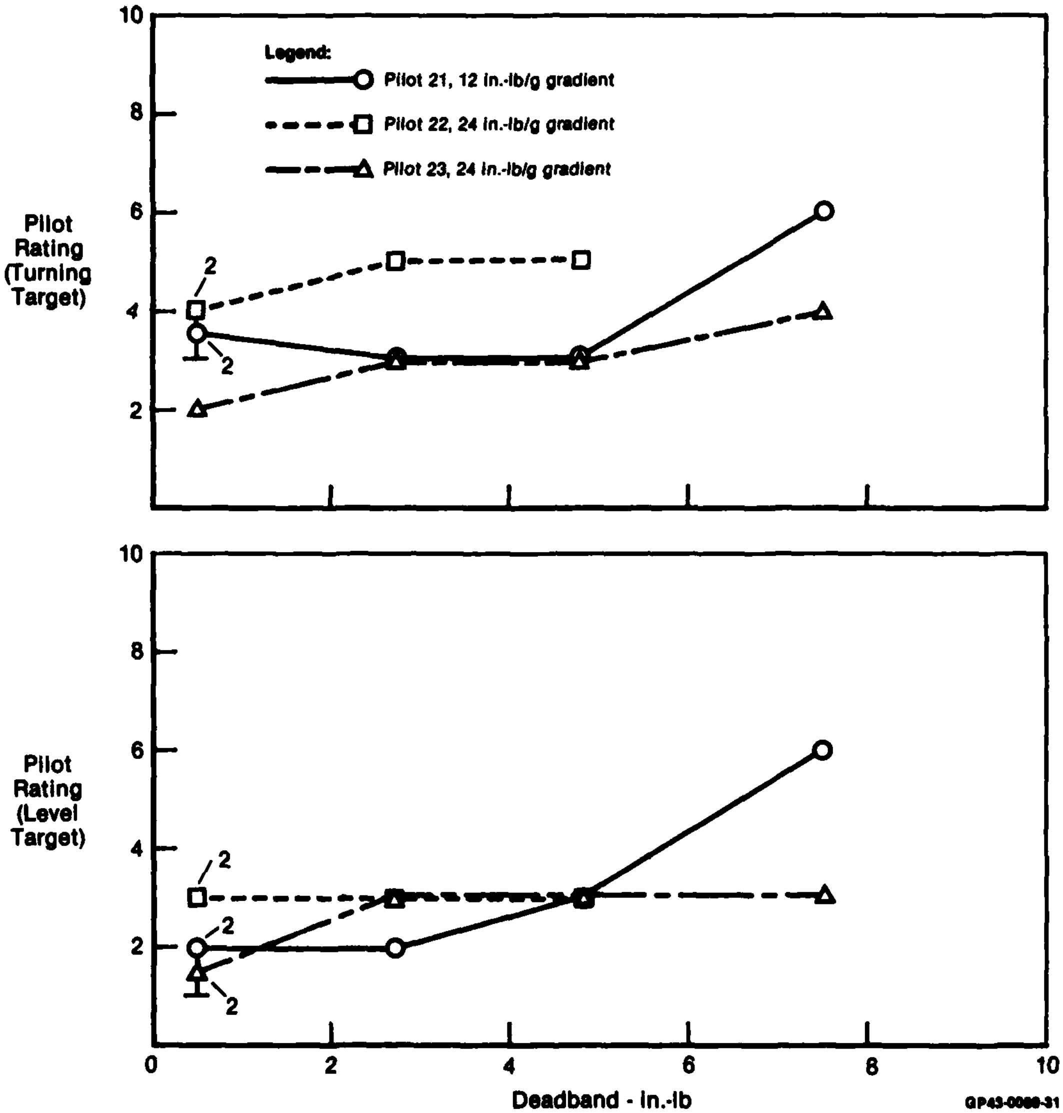


Figure 87. Pilot Rating vs Deadband
Twist Grip Sidestick Wings Level Turn

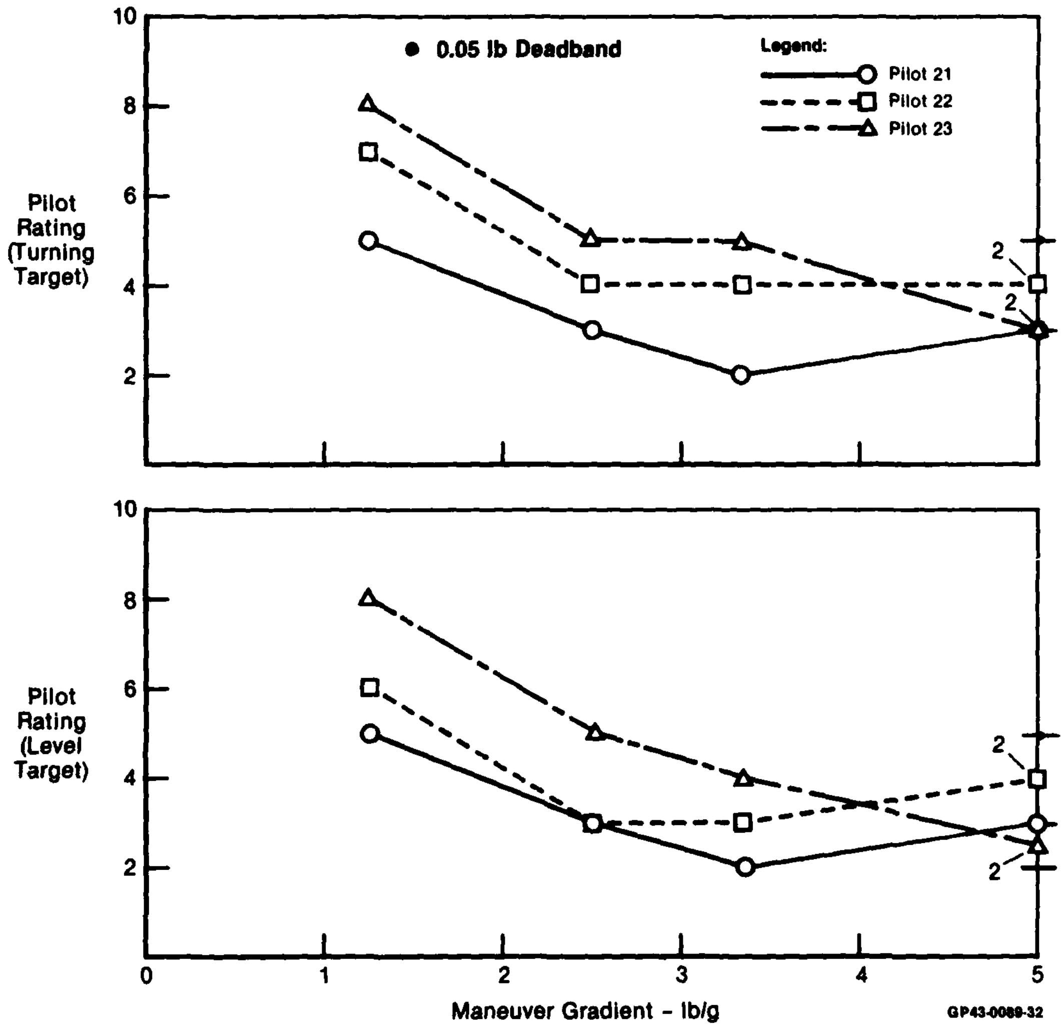


Figure 88. Pilot Rating vs Maneuver Gradient
Thumb Button Controller   Wings Level Turn

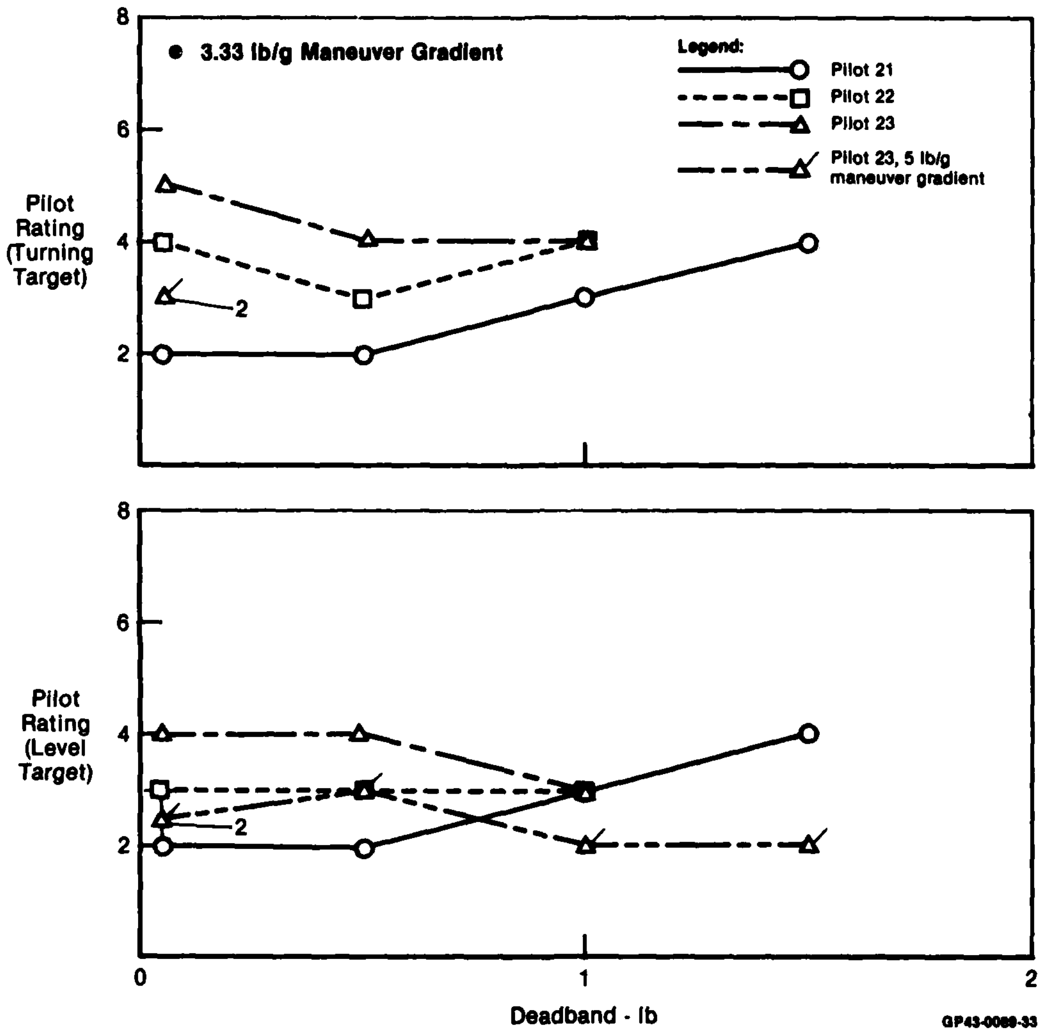


Figure 89. Pilot Rating vs Deadband
Thumb Button Controller   Wings Level Turn

Figures 80 and 81 compare Pilots 21's and 23's evaluation of the one inch maximum rudder pedal configurations. As indicated by his ratings, Pilot 21 liked the one inch throw. Pilot 23 on the other hand indicated he had some problems making small inputs. With the 40 lb/g gradient he found himself overshooting the target during the turning target evaluations. Satisfactory results were obtained with the 60 lb/g gradient. The breakout variations for Pilot 21 had been done with a 20 lb/g maneuver gradient during the first simulation. Due to Pilot 23's preference for the 60 lb/g gradient, this value was used during this breakout variation. The difference in desired maneuver gradients is thought to be due to the difference in pilot technique mentioned above, i.e., use of the toes versus the whole leg. The results of the variations are shown in Figure 81. It is interesting to note that Pilot 21, using the lighter gradient, appears to be more sensitive to breakout variations than Pilot 23 using the stiffer gradient. A review of the pilot comments in Appendix E indicates that Pilot 23 noticed the higher breakouts at the 15 lb level. He commented that the configuration seemed sluggish, especially around neutral; however, he felt the compensation required was minimal and assigned a CH=3.

Figures 82 and 83 present the pilot rating data for the three inch pedal deflection configuration. Due to some experimentation with tasks, the level target data is not directly comparable. For these evaluations the level target that Pilot 21 saw was executing 30% higher amplitude bank angles than the target used for Pilot 23. These are referred to as the faster target points on the plots. The turning targets were identical. Neither pilot really liked the three inch pedal deflection as compared to the shorter throws. Pilot 23 commented on some difficulties with predictability using the 3 inch throw. Pilot 21's comments for the 20 lb/g configuration emphasize the importance of proper maneuver gradient selection. His comments indicate that he perceived this configuration to have less damping, with considerable overshoots. Since the wings level turn response was modeled as first order transfer function and the dynamics were never changed, this decrease in apparent damping can only be due to his rudder pedal inputs acting through the rudder pedal characteristics.

Pilot 21's ratings for the breakout variation shown in Figure 83 indicated definite degradation in pilot rating for breakouts greater than 10 lb. The same trends appear in Pilot 23 evaluations but are emphasized more by examining his comments. The CH=4 shown for the 7 lb breakout case was from the first evaluation of the three inch deflection. His only negative comment was that he was a little slow getting on target. His comments on the 15 and 20 lb breakouts, however, indicate definite problems. For these configurations he found himself making many small reversing pedal inputs around neutral when following the target during bank angle reversals. Again, in his opinion this was not severe enough to warrant increasing his ratings above a CH=4.

All three pilots examined the two inch pedal deflection configurations. By examining both the level and turning target data presented in Figure 84, it appears that the preferred maneuver gradient would be in the region near 40 lb/g. There are no apparent explanations for the large dispersions in Pilot 22's ratings as shown on this figure.

Before examining the breakout variation, a few words discussing Pilot 23's ratings are in order. The two inch displacement pedal configuration was the first pedal configuration examined by this pilot. He had already examined the twist grip sidestick and thumb button controller. On the first day of testing with the pedals, we conducted the maneuver gradient variation followed by the breakout variation using the 40 lb/g maneuver gradient. The pilot had had what can best be described as a "bad" day. It is apparent from the pilot comments that as the session progressed, it became difficult for him to concentrate. A review of the comments indicates that he began blaming problems on himself rather than the configurations. As a result he attempted to compensate his ratings accordingly. Because of this the ratings from this session should be viewed with some skepticism.

In an attempt to save time, on the following day, Pilot 23 was asked to pick a desired maneuver gradient during the warmup session. The pilot selected a value of 20 lb/g. The breakout variation was then repeated. His comments indicated that as the session rolled on, the light gradient became a handicap. It resulted in some sensitivity problems. These problems seemed to confuse the pilot. It is not clear why his ratings improved with increasing breakout as shown in the level target data of Figure 85. One possibility is that the pilot preferred to modulate his pedal inputs around a certain force level, and the higher breakouts provide a means of reaching this value without using excessively steep gradients.

The level target breakout rating data shown in Figure 85 for Pilot 21 indicates a degradation of rating at a breakout value of 10 lb. For Pilot 22 the degradation begins at breakout of 15 lb. The pilot ratings for the turning target task are somewhat confusing. The trends seem to indicate no real preference for breakout in the range of 4 to 15 lb examined by Pilots 21 and 22. Indeed, Pilot 22's ratings appear to improve with increasing breakout. Since in general the evaluations were conducted using smaller breakouts first and testing the higher breakouts last, we may be seeing some pilot learning effects. That is, once a gradient has been selected, if breakout is not really a big driver, one would expect the ratings to improve with increased "practice" using the same gradient.

These comments apply to the turning target task in particular. It was observed during this task that the pilots would be so intent on maintaining a tracking solution that they would end up inadvertently cross-coupling their wing level turn and roll control. The target was performing very small roll perturbations

about a mean 60 degree bank. In some cases the pilots would find themselves with nearly 80 degrees of bank and large amounts of wings level turn command in the opposite direction. So intent were the pilots on maintaining the solution, that they often would not notice what was happening until the problem became very extreme. If they did realize the situation, they found it difficult to return to the proper technique of matching target bank angle without breaking the tracking solution. This problem was not as extreme when using the other controllers. These controllers were incorporated in the sidestick controller, thus the pilots right hand was making all the inputs to the aircraft. As a result the pilot may have had better awareness of his inputs. It is felt that this problem was a result of the artificially long (60 sec) tracking periods, the motivational technique of using feedback of aiming scores and not an inherent problem of wings level turn usage. Graphic illustration of this effect will be illustrated on the discussion of the time history data presented later in this section.

The maneuver gradient and deadband variations for the twist grip sidestick are presented in Figures 86 and 87. It is obvious that Pilot 23 was much more sensitive to maneuver gradient variations than the other two pilots. Pilot 23 also found this controller to be easier to use in the turning target task. Based on the level target rating data it would appear the best results would be obtained using maneuver gradients between 24 and 36 inch-pounds per g. The data shown for Pilot 21 in Figure 87 indicates a definite degradation in pilot rating with increasing deadband. While the ratings show little or no effect for increasing deadband, a review of the pilot comments indicates this was not necessarily the case. With the initial increase in deadband beyond the baseline .48 in-lb used in the maneuver gradient variations, all pilots commented on the increased force required to achieve the desired response. As the deadband increased, the pilots continued to comment on the increased force required. The changes made appeared more as an increase in maneuver gradient to the pilots. At the 4.8 in-lb level, Pilot 21 complained of a delay in the response as well as an increase in required force. At this level Pilot 23 felt that he was jerky on his control inputs and tended to overshoot the target. At the highest level tested, 7.5 in-lb, Pilot 21 complained that too much force was required and that there was not enough sensitivity in the level target task. In the turning target task he stated:

> "It takes too much to get it going and then it's underdamped when it does go. You can't stop it and it wallows all over."

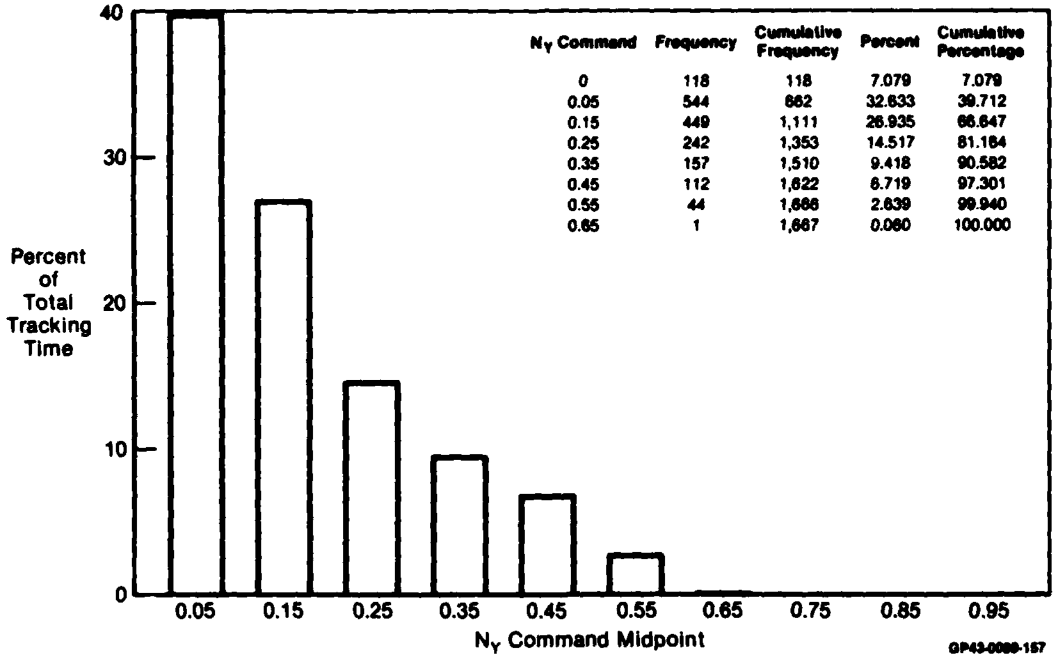
Pilot 23 commented at this point that he was twisting and getting nothing. In the case of the level target he felt he could compensate and gave a CH=3. For the turning task he found he had to degrade to a CH=4. The reader should note that Pilot 21 used a lighter maneuver gradient than did 22 or 23. How much this

influenced his sensitivity to the deadband is difficult to judge. It is consistent with the effect of breakout observed in the one inch deflection rudder pedals.

The maneuver gradient and deadband variations for the thumb controller are presented in Figures 88 and 89. All the pilots were sensitive to variations in maneuver gradient. With the 1.25 lb/g gradient in the level target task, Pilot 23 entered a large amplitude pilot induced oscillation (PIO) that forced him to release the button and re-acquire the target using conventional control before continuing the evaluation. For Pilots 21 and 22, the 3.33 lb/g gradient seemed to work best and was selected for use in the deadband variations. Pilot 23 preferred the 5.0 lb/g gradient. He evaluated the deadband variations using the 3.33 lb/g gradient in both tasks and also the 5.0 lb/g gradient in the level target task. Increasing deadband seems to have had little effect on pilot rating; indeed, values of .5 and 1.0 lb resulted in slight improvements in some cases. It is believed these may be attributed to learning effects as much as anything else. It is interesting to note that using the 5 lb/g gradient, each pound of breakout reduced Pilot 23 maximum authority by 20%. At the 1.5 lb level he could command only .7 g of wings level turn. This appears to have had no effect on his accomplishment of the task. The major comment associated with the increase in deadband was an increase in force required to reach the desired response.

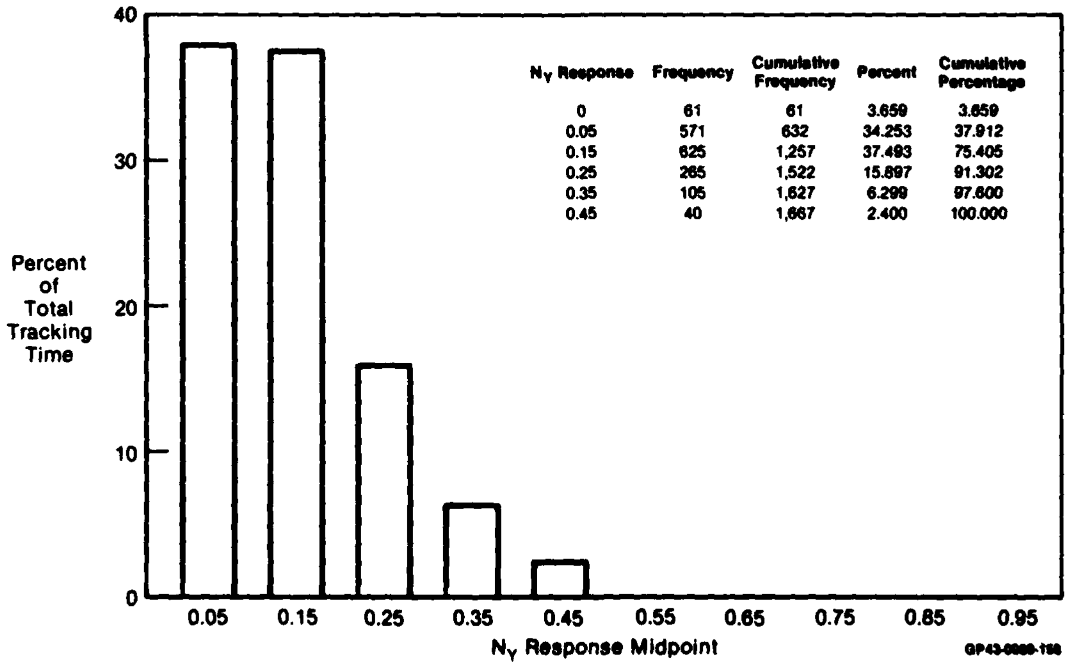
Pilot 21 preferred the thumb button controller followed by the twist grip, two inch, one inch and three inch deflection pedals in that order. Pilot 22 and 23's order of preference was rudders, twist, button. Pilot 21 commented that the button gave him a feeling of direct link between thumb and aiming reticle. He felt he could "think" the pipper to the target with this controller.

The time history data recorded during the simulation was used to examine the amount and method of uncoupled control used by the pilots in the air-to-air turning target task. Histograms were created which indicate the amount and frequency of occurrence of lateral load factor commanded by the pilot and response achieved by the aircraft. All histograms were compiled using a 50 sec period of the task. Data was sampled every .03 seconds. Figure 90 shows the Ny commanded by Pilot 21 during one evaluation. The controller used was the thumb controller configured with a 5.0 lb/g maneuver gradient and .05 lb. deadband. The height of the bars indicates the percentage of time the pilot's command was at a level inside a tenth of a 'g' band centered at the midpoints shown on the horizontal axis. The tabulated data indicates for each command level (zero and the midpoint of each band) the number of occurrences observed (frequency), cumulative number of observations (cumulative frequency), percent of total observations at that level (percent), and the cumulative percentage of observations (cumulative percentage). Figure 91 is a histogram of the aircraft response achieved during the same



N_Y Command	Frequency	Cumulative Frequency	Percent	Cumulative Percentage
0	118	118	7.079	7.079
0.05	544	662	32.633	39.712
0.15	449	1,111	26.935	66.647
0.25	242	1,353	14.517	81.164
0.35	157	1,510	9.418	90.582
0.45	112	1,622	6.719	97.301
0.55	44	1,666	2.639	99.940
0.65	1	1,667	0.060	100.000

Figure 90. Commanded N_y
Pilot 21 - Thumb Button
5 Lb/g Gradient   0.05 Lb Deadband

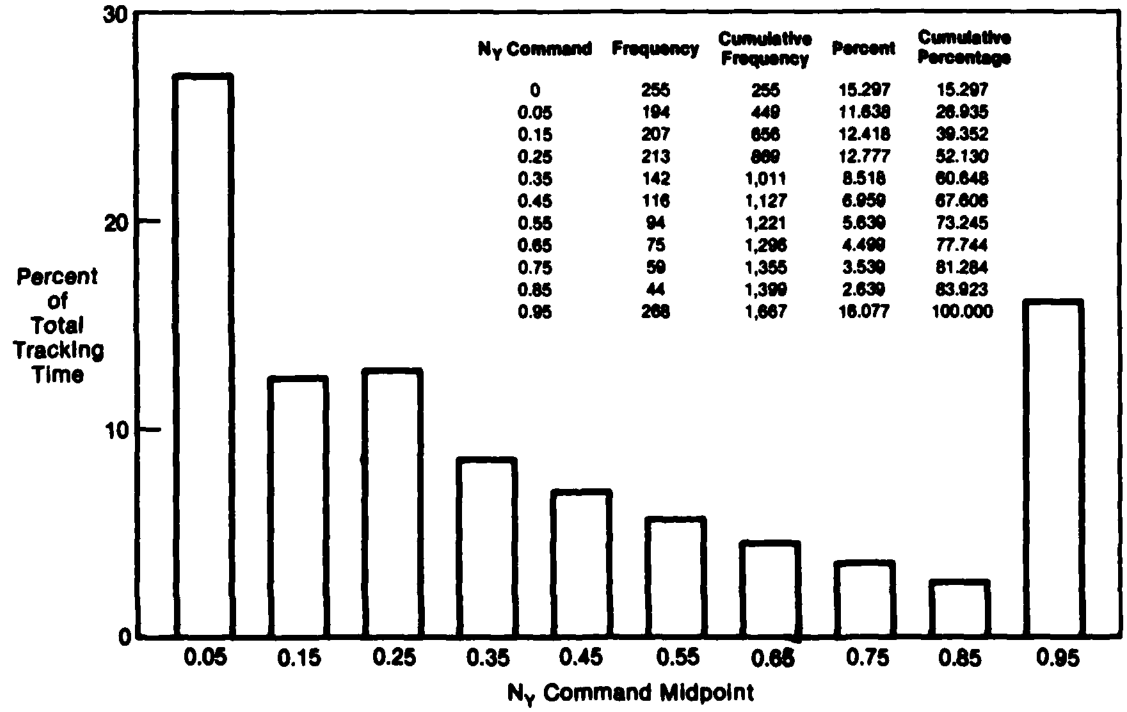


N_Y Response	Frequency	Cumulative Frequency	Percent	Cumulative Percentage
0	61	61	3.659	3.659
0.05	571	632	34.253	37.912
0.15	625	1,257	37.493	75.405
0.25	265	1,522	15.897	91.302
0.35	105	1,627	6.299	97.600
0.45	40	1,667	2.400	100.000

Figure 91. Response N_y
Pilot 21 - Thumb Button
5 Lb/g Gradient   0.05 Lb Deadband

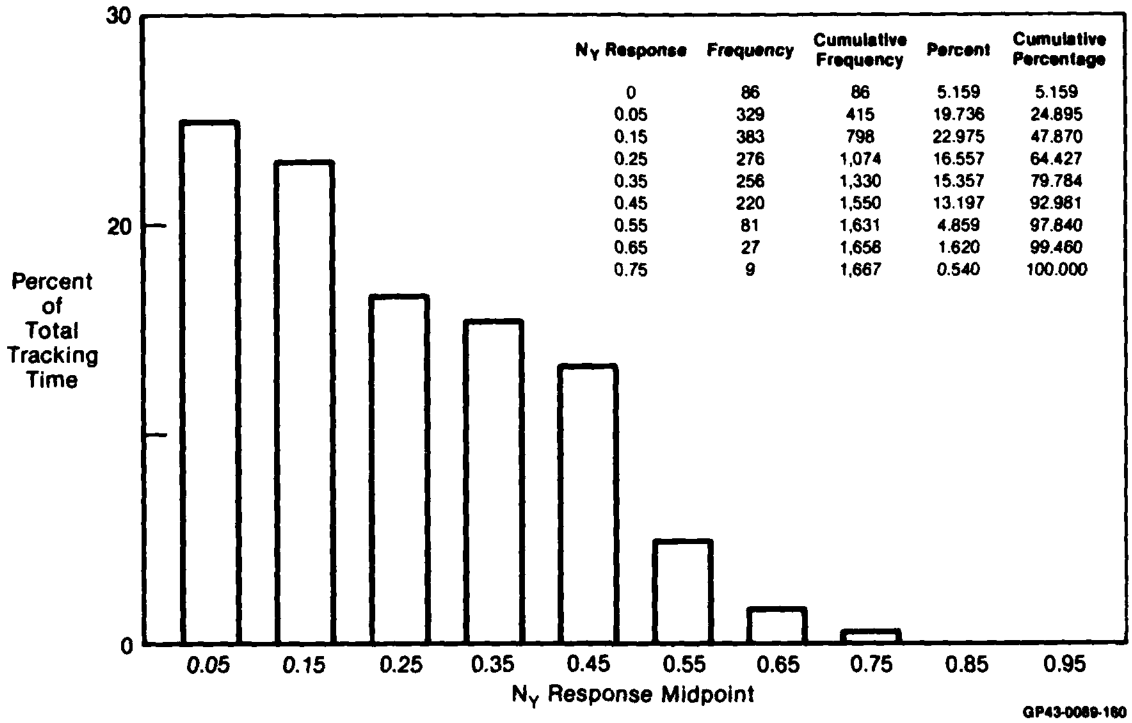
run. All of the comments on the previous histogram apply here except that Ny response is the observed variable rather than Ny commanded. In both plots, notice the smooth dropoff of occurrences with increasing amplitude. This is felt to be indicative of the use of the mode as a fine tracking device with the pilot applying proportional control techniques. The pilot assigned a CH=3 to this configuration with no negative comments.

Figures 92 and 93 are command and response histograms for the same pilot and controller. However, for this run the thumb controller was configured with a 1.25 lb/g maneuver gradient and .05 lb. deadband. Note the change in shape of the command histogram. Initially the number of observations drops off with increasing amplitude, indicating some form of proportional control. However, a large spike occurs at full wings level turn command. This indicates an "on-off" or "bang-bang" use of the controller. Unable to achieve satisfactory results using a proportional control technique, the pilot applies full command until the desired response is achieved and then removes the command. The pilot assigned a CH=5 to this configuration, commenting that it was "too sensitive to hold on target." It is felt that this blending of proportional and on-off control is an attempt by the pilot to compensate for controller deficiencies by changing his control technique.



N_Y Command	Frequency	Cumulative Frequency	Percent	Cumulative Percentage
0	255	255	15.297	15.297
0.05	194	449	11.638	26.935
0.15	207	656	12.418	39.352
0.25	213	869	12.777	52.130
0.35	142	1,011	8.518	60.648
0.45	116	1,127	6.959	67.606
0.55	94	1,221	5.639	73.245
0.65	75	1,296	4.499	77.744
0.75	59	1,355	3.539	81.284
0.85	44	1,399	2.639	83.923
0.95	268	1,667	16.077	100.000

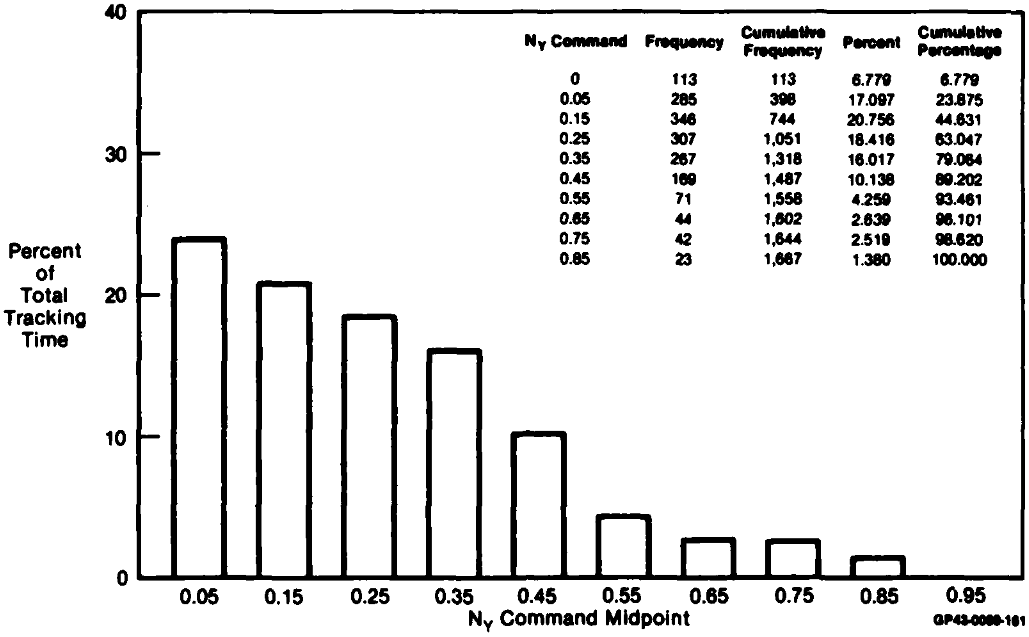
Figure 92. Commanded N_y
Pilot 21 - Thumb Button
1.25 Lb/g Gradient 0.05 Lb Deadband



N_Y Response	Frequency	Cumulative Frequency	Percent	Cumulative Percentage
0	86	86	5.159	5.159
0.05	329	415	19.736	24.895
0.15	383	798	22.975	47.870
0.25	276	1,074	16.557	64.427
0.35	256	1,330	15.357	79.784
0.45	220	1,550	13.197	92.981
0.55	81	1,631	4.859	97.840
0.65	27	1,658	1.620	99.460
0.75	9	1,667	0.540	100.000

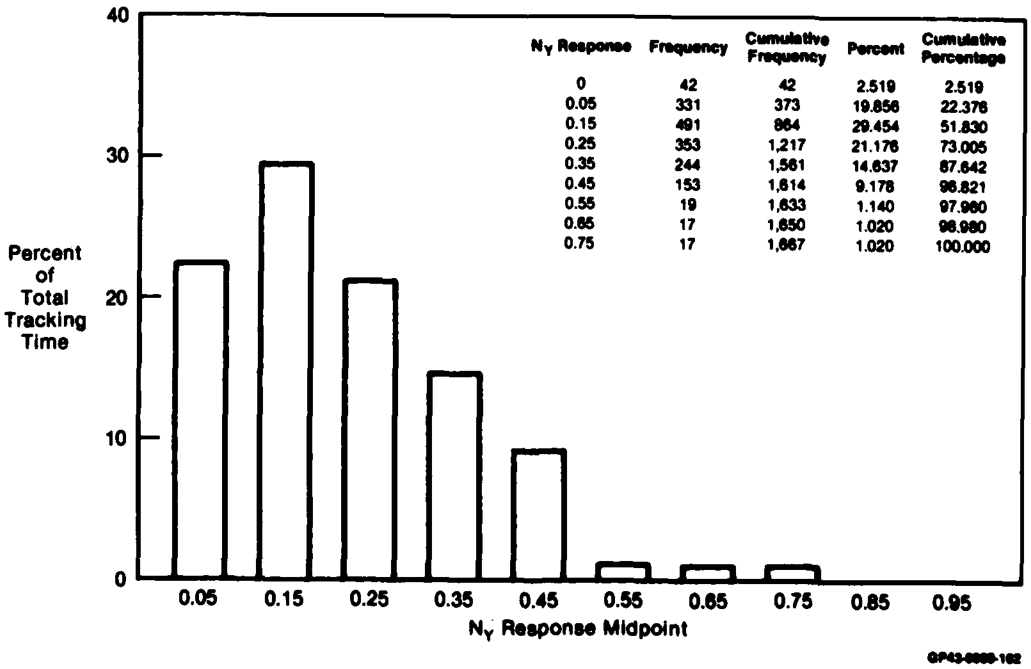
Figure 93. Response N_y
Pilot 21 - Thumb Button
1.25 Lb/g Gradient 0.05 Lb Deadband

Figures 94 and 95 are command and response histograms for Pilot 23 using the thumb controller configured with the 5.0 lb/g maneuver gradient and .05 lb deadband. This pilot also exhibits the smooth rolloff in occurrences with increasing amplitude and we see commands out to the .85g level. This is quite a bit higher than the .65g level used by Pilot 21 in the same task and configuration. Pilot 23 rated this configuration a CH=3. However, he did comment on problems with some minor overshoots. These overshoots may be either the cause or result of the higher command levels. More detailed analysis of time history plots would be necessary to determine if such a relationship exists.



N_Y Command	Frequency	Cumulative Frequency	Percent	Cumulative Percentage
0	113	113	6.779	6.779
0.05	285	398	17.097	23.875
0.15	346	744	20.756	44.631
0.25	307	1,051	18.416	63.047
0.35	267	1,318	16.017	79.064
0.45	169	1,487	10.138	89.202
0.55	71	1,558	4.259	93.461
0.65	44	1,602	2.639	96.101
0.75	42	1,644	2.519	98.620
0.85	23	1,667	1.380	100.000

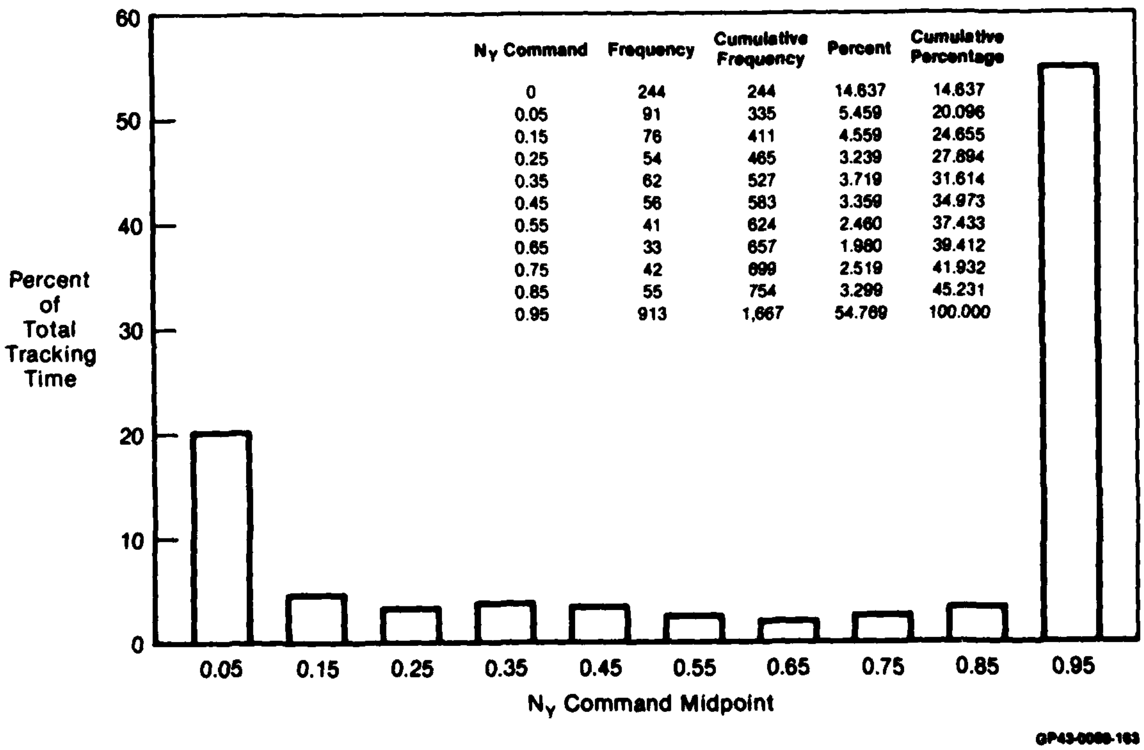
Figure 94. Commanded N_y
Pilot 23 - Thumb Button
5 Lb/g Gradient 0.05 Lb Deadband



N_Y Response	Frequency	Cumulative Frequency	Percent	Cumulative Percentage
0	42	42	2.519	2.519
0.05	331	373	19.856	22.376
0.15	491	864	29.454	51.830
0.25	353	1,217	21.176	73.005
0.35	244	1,561	14.637	87.642
0.45	153	1,614	9.178	96.821
0.55	19	1,633	1.140	97.960
0.65	17	1,650	1.020	98.980
0.75	17	1,667	1.020	100.000

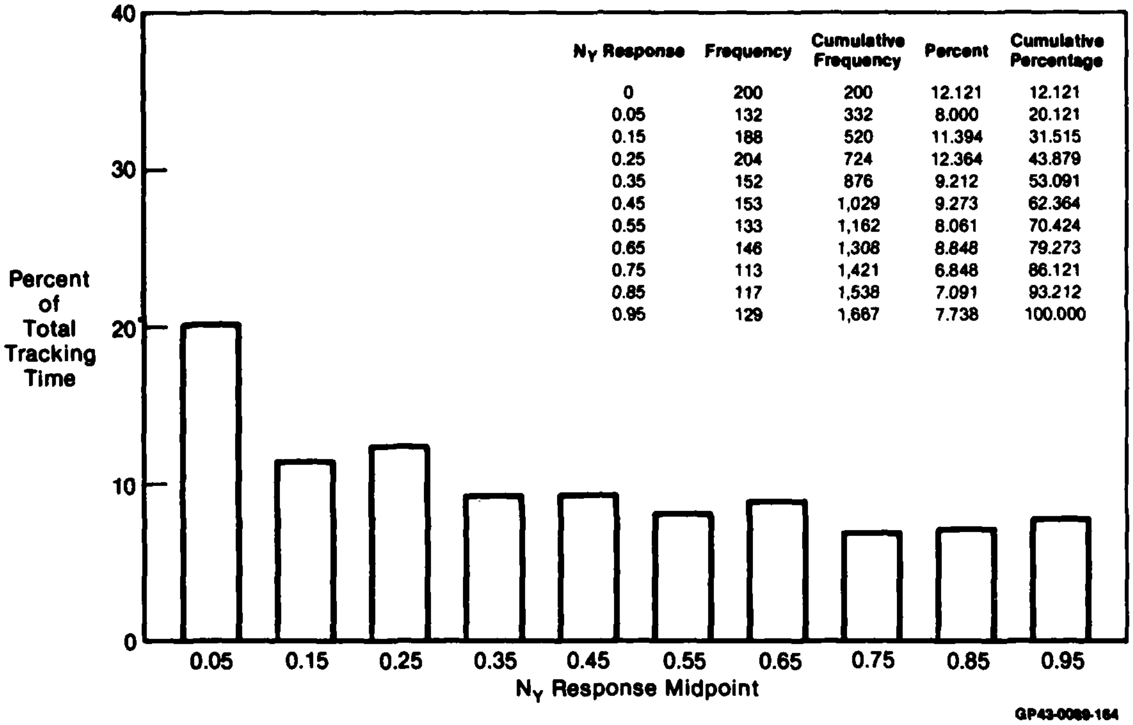
Figure 95. Response N_y
Pilot 23 - Thumb Button
5 Lb/g Gradient 0.05 Lb Deadband

The results for the 1.25 lb/g evaluations by pilot 23, shown in Figures ^6 and 97, clearly indicate the use of a "bang-bang" control technique to try to control the aircraft. The majority of the inputs are either from zero to full stop or from stop to stop with very little time spent at levels in between these points. A review of the response data of Figure 97 shows that the aircraft had responses all the way to the maximum of 1g side-force. Pilot 23 assigned this configuration a CH=8, commenting that he felt considerable pilot compensation was required to maintain control in the task. While tracking during the level target task, Pilot 23 developed a large amplitude pilot-induced oscillation (PIO) that required him to remove his thumb from the control and reacquire the target conventionally before tracking could continue.



N_Y Command	Frequency	Cumulative Frequency	Percent	Cumulative Percentage
0	244	244	14.637	14.637
0.05	91	335	5.459	20.096
0.15	76	411	4.559	24.655
0.25	54	465	3.239	27.894
0.35	62	527	3.719	31.614
0.45	56	583	3.359	34.973
0.55	41	624	2.460	37.433
0.65	33	657	1.980	39.412
0.75	42	699	2.519	41.932
0.85	55	754	3.299	45.231
0.95	913	1,667	54.769	100.000

Figure 96. Commanded N_y
Pilot 23 - Thumb Button
1.25 Lb/g Gradient   0.05 Lb Deadband



N_Y Response	Frequency	Cumulative Frequency	Percent	Cumulative Percentage
0	200	200	12.121	12.121
0.05	132	332	8.000	20.121
0.15	188	520	11.394	31.515
0.25	204	724	12.364	43.879
0.35	152	876	9.212	53.091
0.45	153	1,029	9.273	62.364
0.55	133	1,162	8.061	70.424
0.65	146	1,308	8.848	79.273
0.75	113	1,421	6.848	86.121
0.85	117	1,538	7.091	93.212
0.95	129	1,667	7.738	100.000

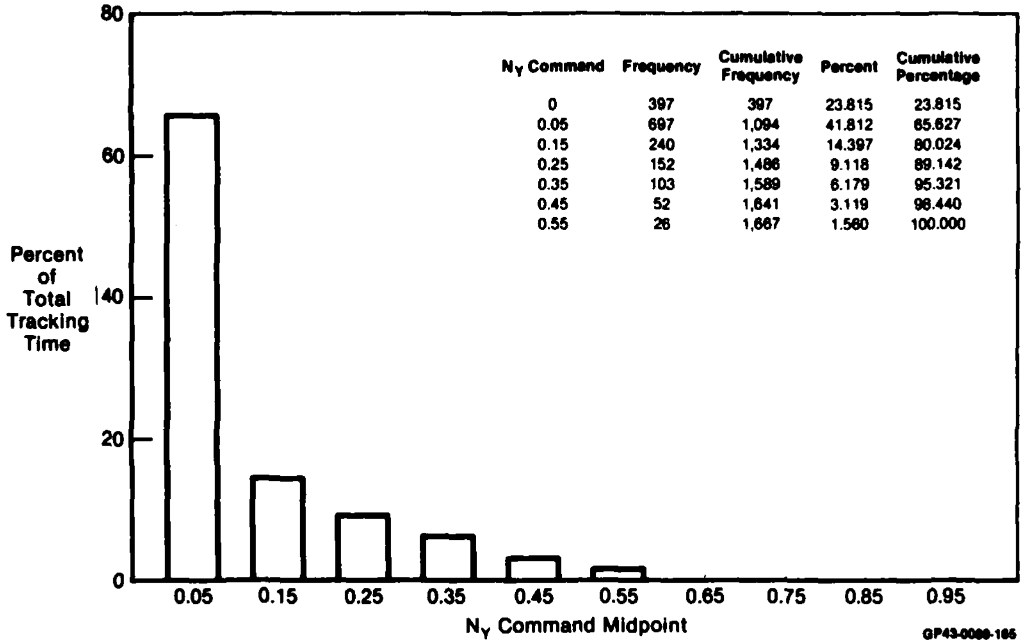
Figure 97. Response N_y
Pilot 23 - Thumb Button
5 Lb/g Gradient   0.05 Lb Deadband

Some comments about the use of the thumb controller are required. The controller motions in response to applied forces are so small that that device appears isometric to the pilot. The pilots differed somewhat in their acceptance of the thumb controller. Pilot 21 found the button simple to use and picked it as his favorite for this portion of the air-to-air evaluations. His comments from the debriefings indicate that he viewed the button as an extension of the HUD reticle. He simply moved his thumb as required to position the reticle over the target. Pilot 23, however, had more problems adapting to the thumb controller. While he found the 'sense' of the control inputs to be natural, he never became really comfortable with the controller. This may help to explain some of the differences observed when comparing the histograms of the two pilots' inputs. As a general observation, it appears the more comfortable a pilot was with a particular controller and configuration, the smoother and lower amplitude his control inputs in the same task.

While the examples shown here represent extremes of configuration variation, they do indicate some important points. First is the large impact that the maneuver gradient can have on pilot opinion. This is an obvious fact, but one that must be remembered. Second, the examples indicate that the pilot changes his control technique based on his perception of the configuration. The pilots had been told before hand that the mode dynamics would not be changed, only the control sensitivity and characteristics about the zero control input point were changed. Still, we received comments about overshoots and oscillatory responses that without this prior knowledge the pilots could easily have perceived as shortcomings in the basic response dynamics. These results also serve as an indication that even without an exact specification of desired and acceptable performance, the pilots still adopted extreme control techniques rather than "backing off" and accepting degraded performance results.

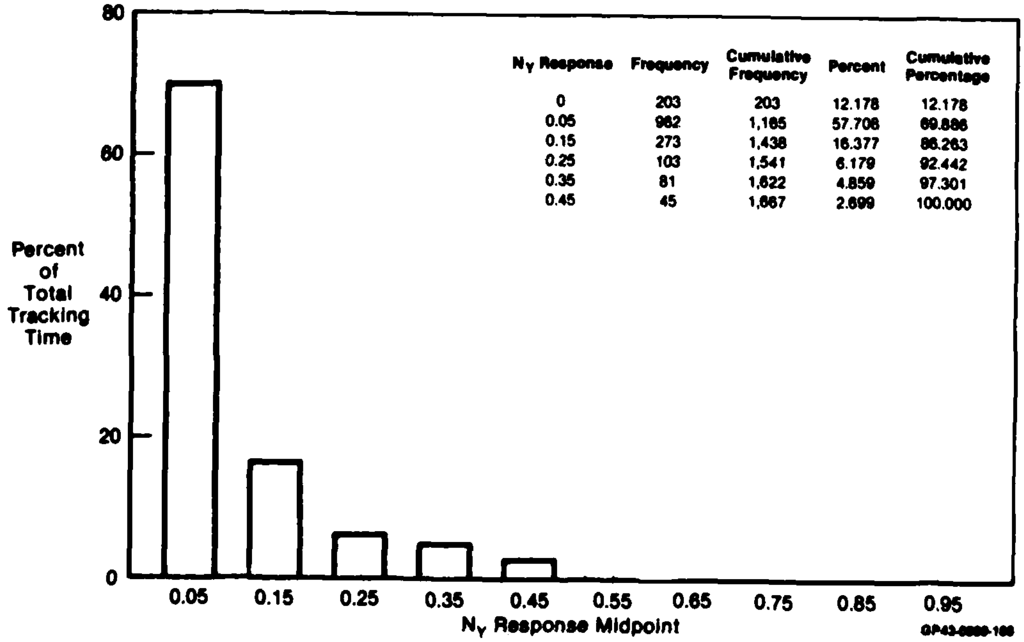
Figures 98 through 101 help to illustrate the coupling problems observed during the rudder pedal evaluations. This phenomenon was discussed in detail in the pilot rating discussions. The problem manifests itself as a tendency to operate the pedals about a position away from neutral. As a result, the pilots would require bank angle in the opposite direction to maintain a constant tracking solution. This was not a modification of the pilots tracking technique to improve control. Rather, it was a condition the pilots drifted into due to the intensity with which they attempted to maintain a tracking solution. If anything, it can be blamed on a lack of finely tuned pilot technique. Figures 98 and 99 illustrate the command and response generated by Pilot 23 in a typical rudder pedal evaluation. Note the low levels of command used. Note also that the response levels nearly equal the command levels. This indicates that the commands were generally applied at frequencies below the 2 rad/sec break frequency of the wings level turn mode since there is little attenuation of the command. The pilot assigned this configuration a CH=3, finding it easy to control.

Figures 100 and 101 are histograms of the wings level turn command and response levels for Pilot 21 using the same configuration. Pilot 22 also found this configuration easy to control and assigned it a CH=3. However, during this run, the pilot quickly drifted into the crossed control condition. The response histogram shown in Figure 100 indicates that the pilot was holding a command of between .25 and .45 g's during most of the run, with variations of $\pm$ .25g about this condition. Assuming a mean of approximately .3 g's commanded, this works out to a constant 19 lb. input force on the pedal. Comparatively this is not a large force to hold for the legs. Pilot 21 was seemingly unaware of the problems. The 4.0 lb/g maneuver gradient was well liked by all the pilots.



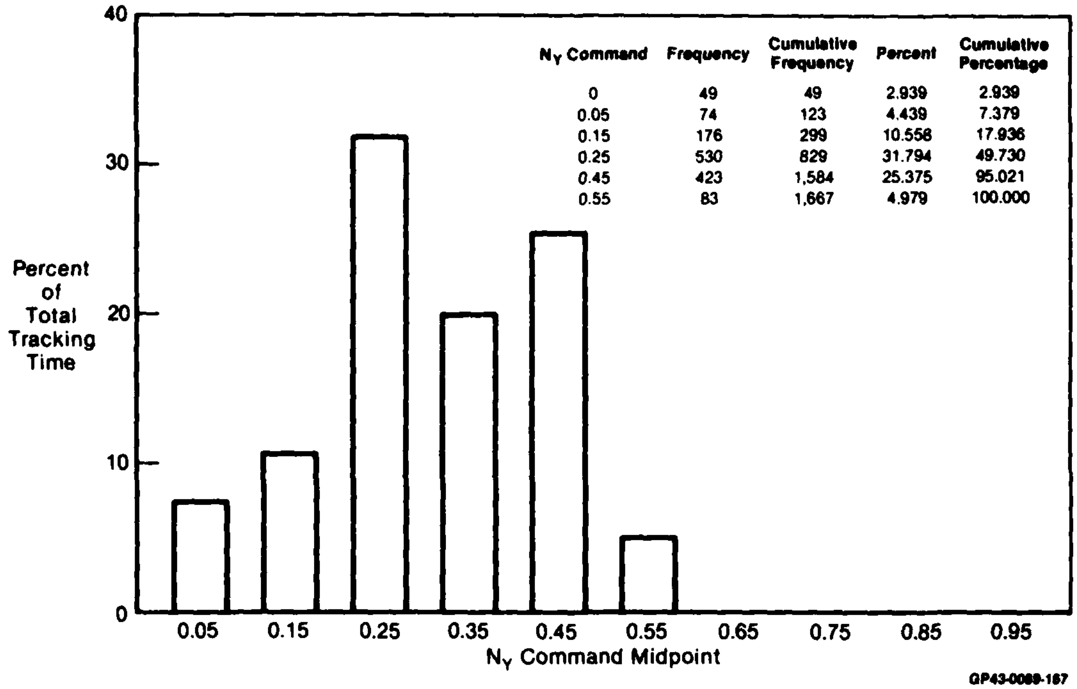
N_Y Command	Frequency	Cumulative Frequency	Percent	Cumulative Percentage
0	397	397	23.815	23.815
0.05	697	1,094	41.812	65.627
0.15	240	1,334	14.397	80.024
0.25	152	1,486	9.118	89.142
0.35	103	1,589	6.179	95.321
0.45	52	1,641	3.119	98.440
0.55	26	1,667	1.560	100.000

Figure 98. Commanded N_y
Pilot 23 - 2 In. Rudder Pedal
40 Lb/g Gradient 7 Lb Breakout



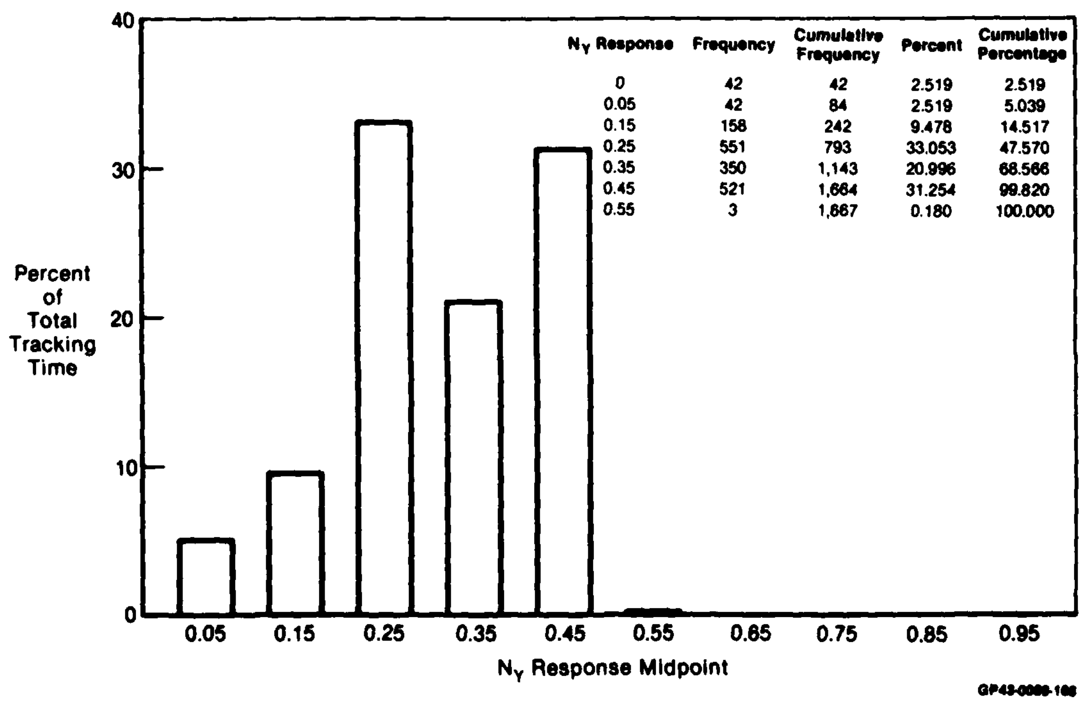
N_Y Response	Frequency	Cumulative Frequency	Percent	Cumulative Percentage
0	203	203	12.178	12.178
0.05	962	1,165	57.708	69.886
0.15	273	1,438	16.377	86.263
0.25	103	1,541	6.179	92.442
0.35	81	1,622	4.859	97.301
0.45	45	1,667	2.699	100.000

Figure 99. Response N_y
Pilot 23 - 2 In. Rudder Pedals
40 Lb/g Gradient 7 Lb Breakout



N_Y Command	Frequency	Cumulative Frequency	Percent	Cumulative Percentage
0	49	49	2.939	2.939
0.05	74	123	4.439	7.379
0.15	176	299	10.558	17.936
0.25	530	829	31.794	49.730
0.45	423	1,584	25.375	95.021
0.55	83	1,667	4.979	100.000

Figure 100. Commanded N_y
Pilot 21 - 2 In. Rudder Pedal
40 Lb/g Gradient   7 Lb Breakout



N_Y Response	Frequency	Cumulative Frequency	Percent	Cumulative Percentage
0	42	42	2.519	2.519
0.05	42	84	2.519	5.039
0.15	158	242	9.478	14.517
0.25	551	793	33.053	47.570
0.35	350	1,143	20.996	68.566
0.45	521	1,664	31.254	99.820
0.55	3	1,667	0.180	100.000

Figure 101. Response N_y
Pilot 21 - 2 In. Rudder Pedal
40 Lb/g Gradient   7 Lb Breakout

While the rudder pedal is the only controller for which the histogram data exhibits this effect, analysis of pilot comments and control techniques indicates that the tendency may have existed with all the controllers. All the pilots commented on having difficulties reacquiring the target if they did pull off. Pilot 21 found himself holding small input levels when using the twist grip sidestick. This may explain the occasional displays of insensitivity to breakout variations discussed earlier.

One of the reasons the tendency was not as severe with the other controllers may have been due to that fact that the problem was discussed with the pilots following their rudder pedal evaluations. For Pilots 21 and 22, the pedals were the first controller used. These discussions may have made them more conscious of the problem in later evaluations. Pilot 23, who's first exposure was to the twist grip, did not have as much problem cross controlling on the pedals. He did have some problems with the thumb controller however.

Pilot 22, while evaluating the thumb controller, talked about his approach to the turning target tasks. "If I'm not close to the pipper, then the first thing I do is get the aim point lined up. Then, if I notice that I've got a mismatch of bank, I'll try to go after correcting that bank but the first part is getting the pipper on target, second is bank. Do you want me to break down how I attack an error?"

The pilot then went on to explain how he performed each of the tasks. Recall that the turning target task began with the target flying straight and level for five seconds. The target rolled into a 2g level turn with small roll perturbations.

"It depends on what the target is doing. Let me talk about the level turn target. The first thing I look for is an azimuth deviation and I go after that with the thumb controller. The second correction is pitch. For a 2g target, the first thing I go after is bank. My first priority is to go after him with bank. If he's rolling away from me - going off to the right - I'll be rolling right and going after him with right wings level turn. But the first part is to bank, I think, but the two inputs are not too far apart. Then I'm making pitch corrections a third after those two."

Several runs later, Pilot 22 added these comments about the turning task: "I think I did reasonably well in the task. I'll give that a 3 also. I find rolling in with that target difficult. I'm not sure the priority of what I said when I roll in is the same the last couple runs. I've noticed that I'm going after him with side force and sensing that I'm drifting, not keeping up with him, then I go with bank. It seems to be a more accurate description of what I'm doing."

The pilot commented that, once a bank angle mismatch developed, he had a coordination problem in determining how to correct the situation without breaking his tracking solution. The other pilots made similar comments. This is a problem which can probably only be rectified by extensive pilot training. It is not expected to have had a substantial roll in determining desirable controller characteristics.

In addition to using the time history data to construct histograms, an attempt was made to correlate lateral and longitudinal pipper error with pilot ratings for each of the controllers. Plots of pipper error standard deviation, expressed in milliradians (mils), versus pilot rating are presented in Figures 102 through 123. When multiple runs were made to reach one rating, error dated for each run was plotted. The points comprising one rating were then connected by a bracket. The use of pipper error standard deviation subtracts out bias in pilot aiming technique, showing only the amount of error about the mean. Figures 102 through 107 present the results for Pilots 21, 22, and 23 using the two inch pedal deflection. Figures 108 through 111 present the error data for Pilot 23 using the one and three inch pedal deflections. The twist grip sidestick error data for all the pilots is shown in Figures 112 through 117 and the thumb button controller data in Figures 118 through 123.

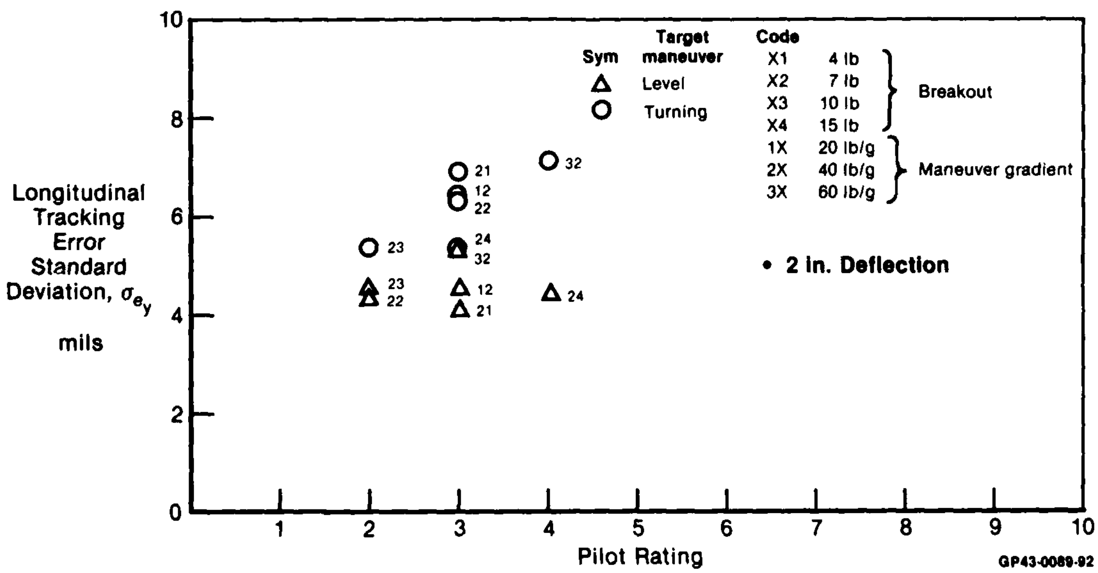


Figure 102. Longitudinal Tracking Error vs Pilot Rating
Rudder Pedals Wings Level Turn Pilot 21

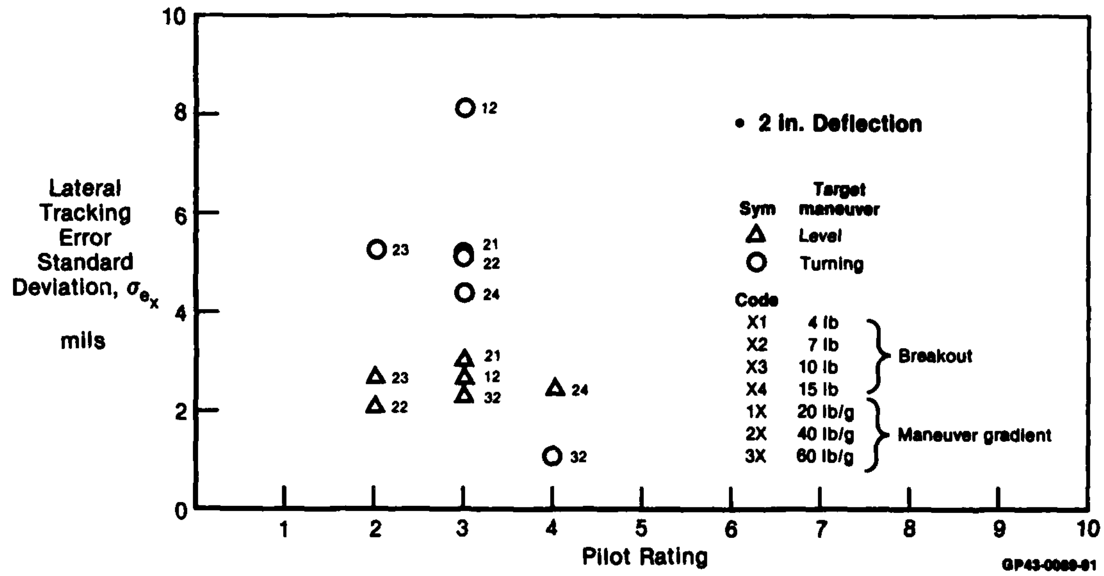


Figure 103. Lateral Tracking Error vs Pilot Rating
Rudder Pedals Wings Level Turn Pilot 21

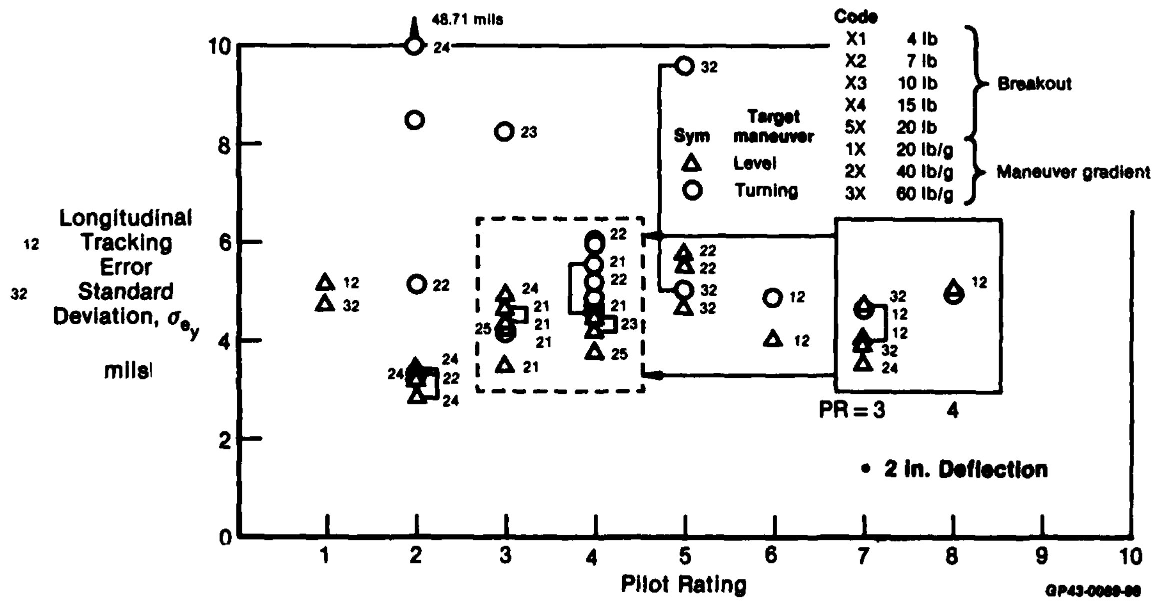


Figure 104. Longitudinal Tracking Error vs Pilot Rating
Rudder Pedals Wings Level Turn Pilot 22

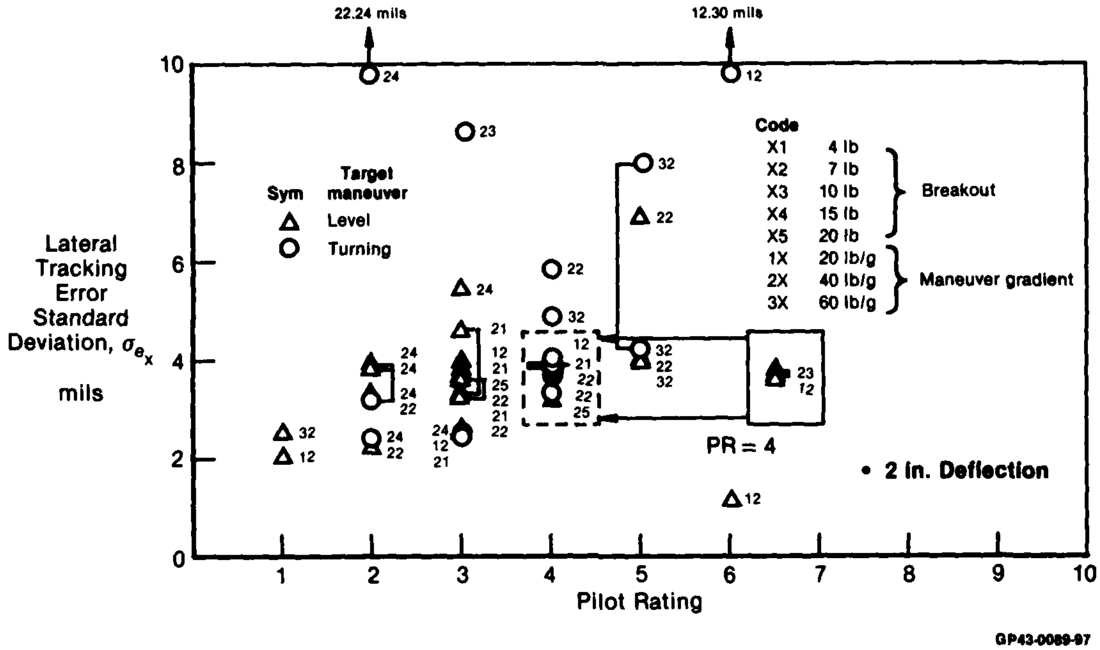


Figure 105. Lateral Tracking Error vs Pilot Rating
Rudder Pedals Wings Level Turn Pilot 22

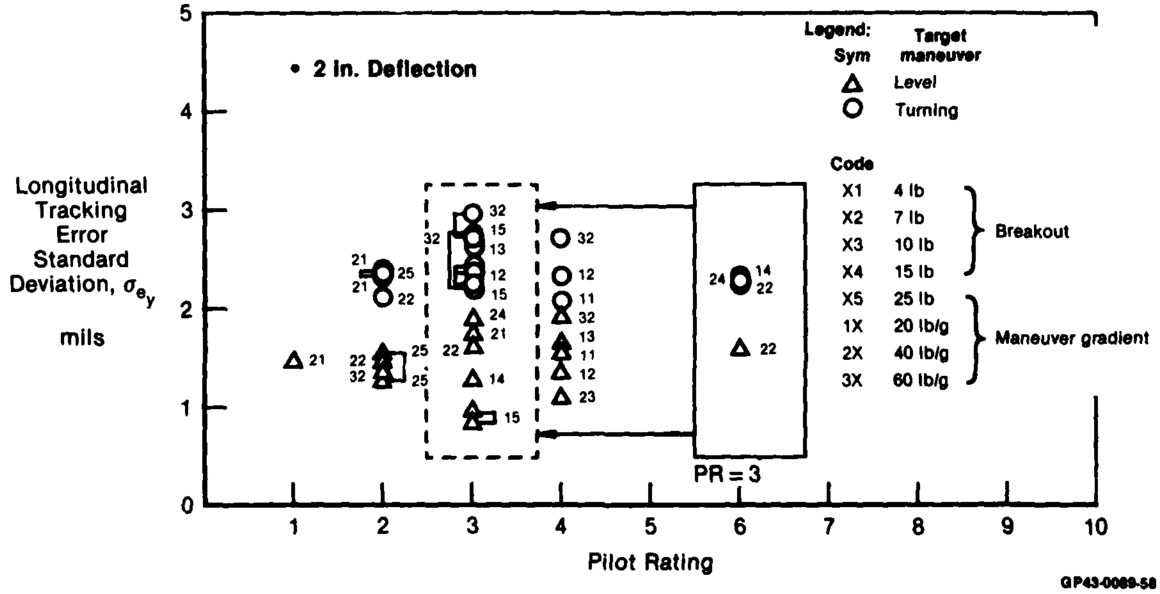


Figure 106. Longitudinal Tracking Error vs Pilot Rating
Rudder Pedals Wings Level Turn Pilot 23

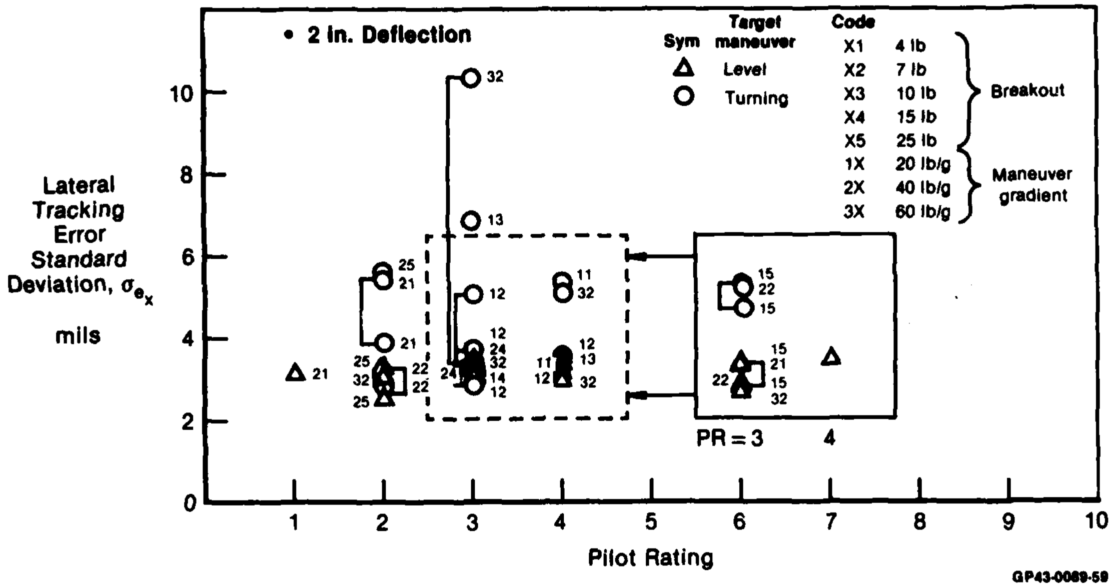


Figure 107. Lateral Tracking Error vs Pilot Rating
Rudder Pedals   Wings Level Turn   Pilot 23

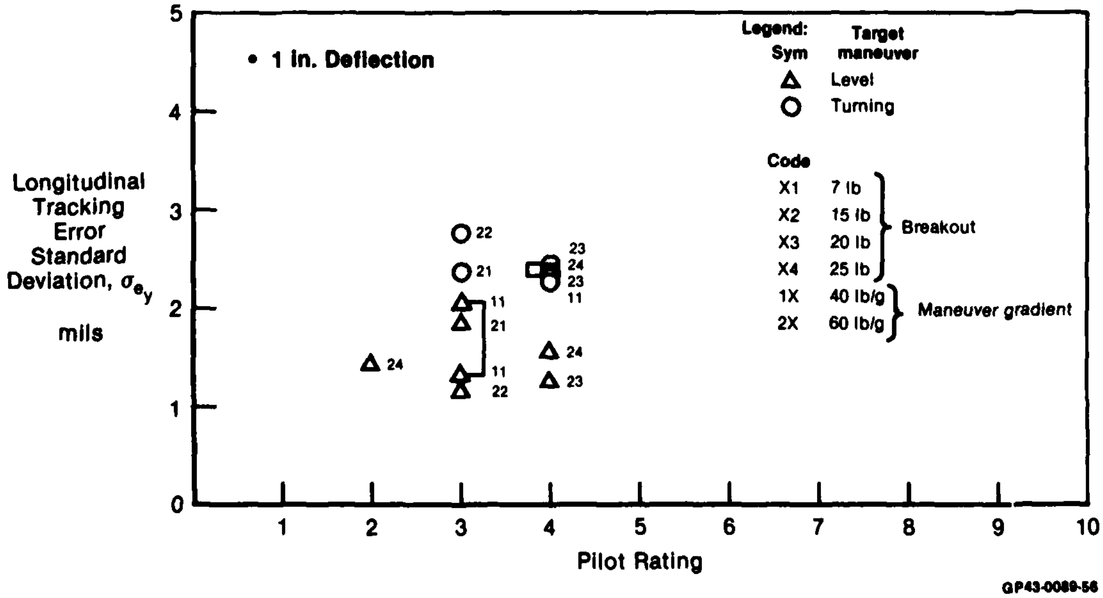


Figure 108. Longitudinal Tracking Error vs Pilot Rating
Rudder Pedals   Wings Level Turn   Pilot 23

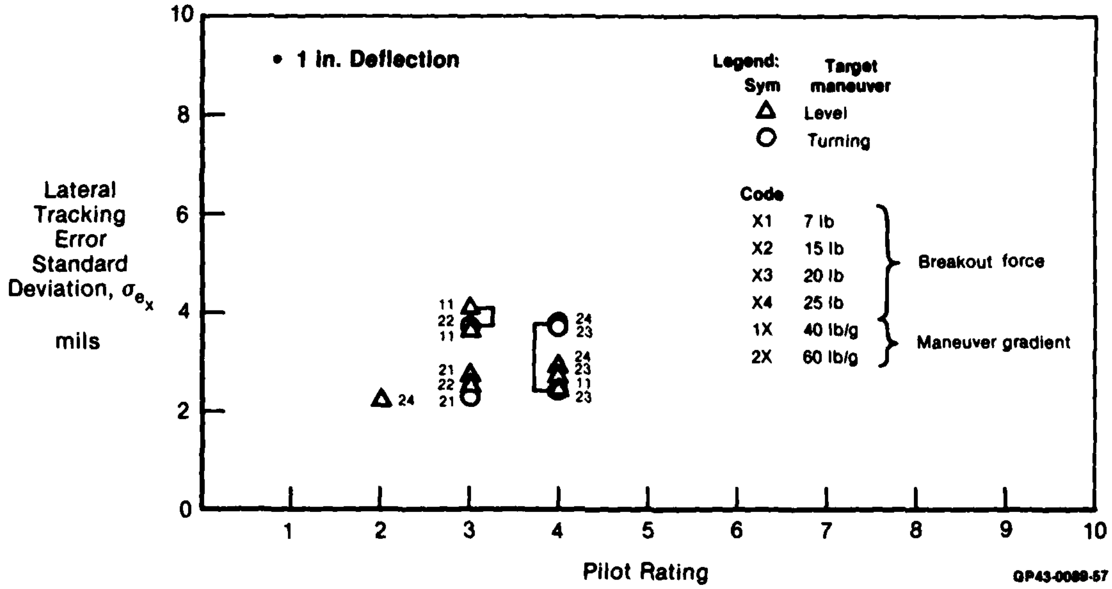


Figure 109. Lateral Tracking Error vs Pilot Rating
Rudder Pedals Wings Level Turn Pilot 23

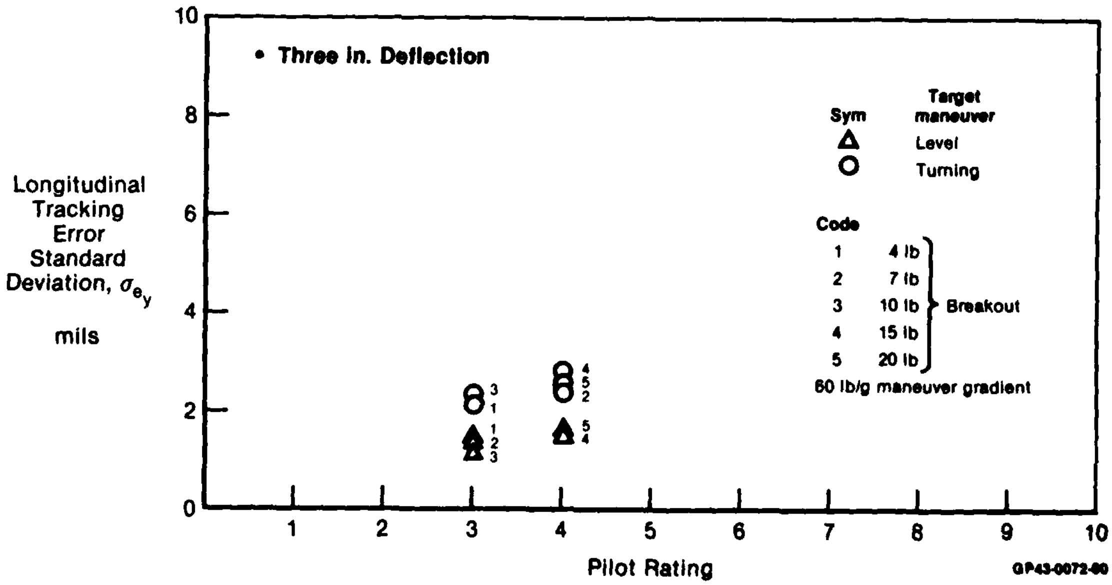


Figure 110. Longitudinal Tracking Error vs Pilot Rating
Rudder Pedals Wings Level Turn Pilot 23

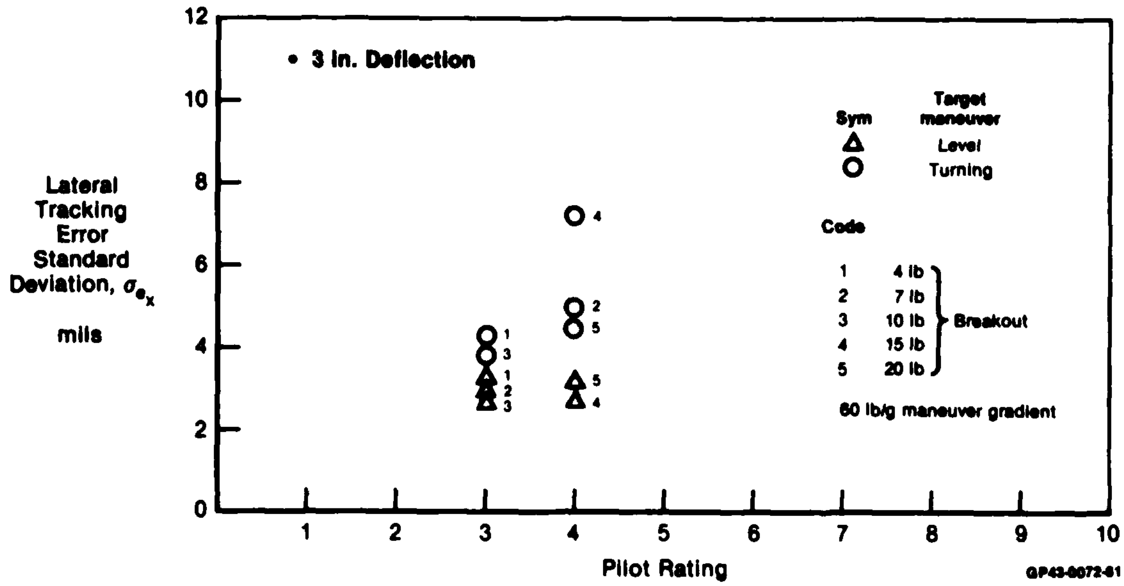


Figure 111. Lateral Tracking Error vs Pilot Rating
Rudder Pedals Wings Level Turn Pilot 23

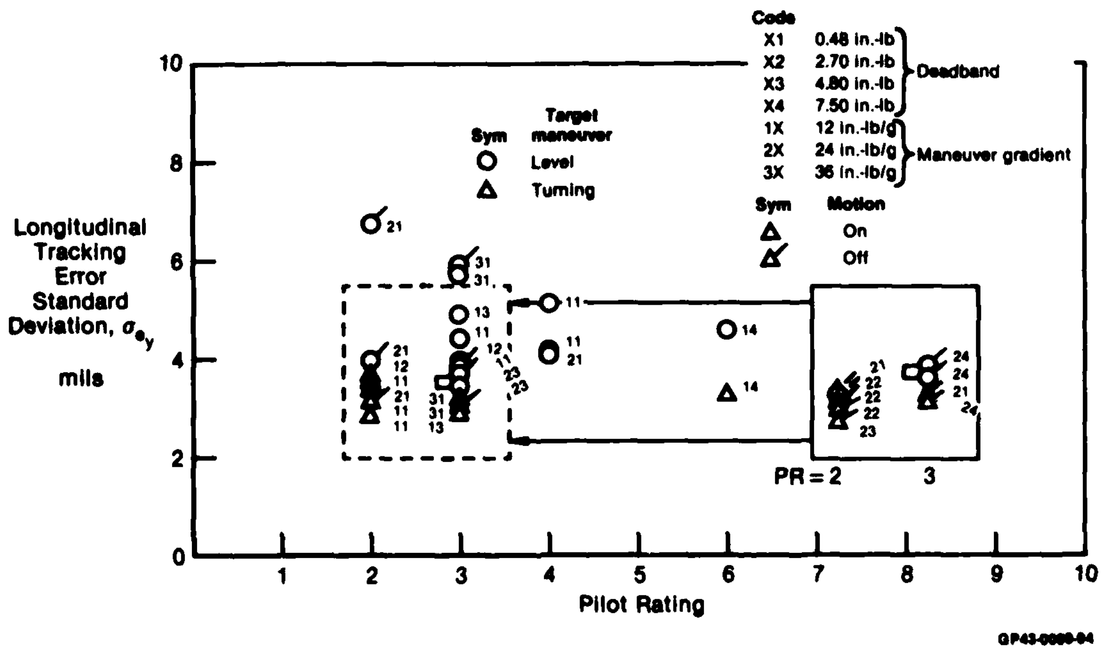


Figure 112. Longitudinal Tracking Error vs Pilot Rating
Twist Grip Sidestick Wings Level Turn Pilot 21

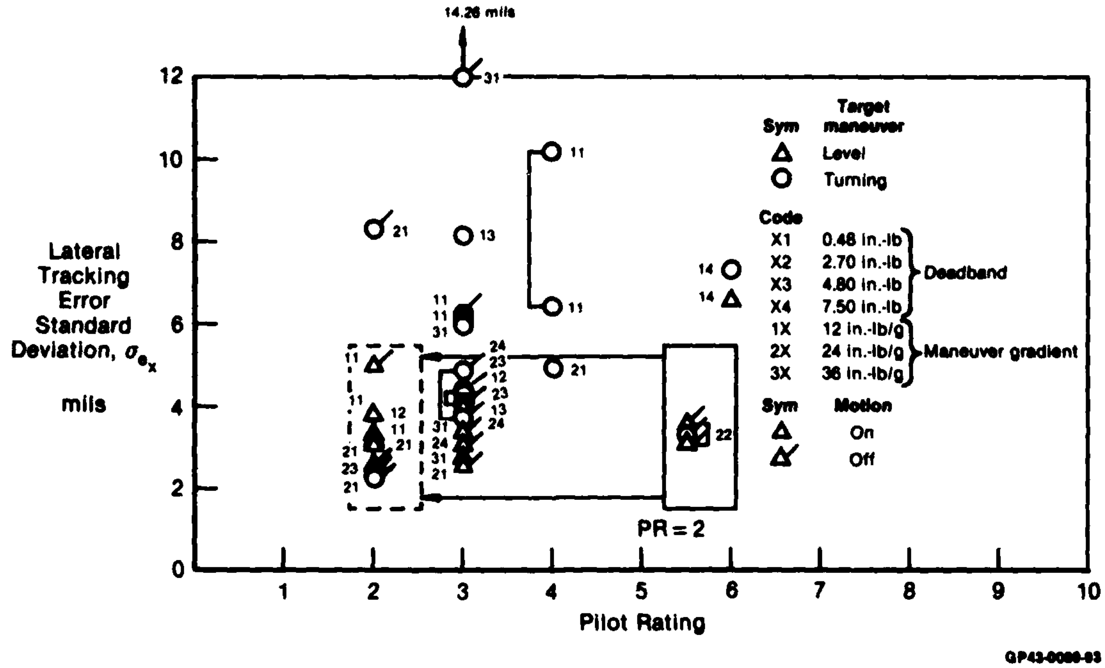


Figure 113. Lateral Tracking Error vs Pilot Rating
Twist Grip Sidestick Wings Level Turn Pilot 21

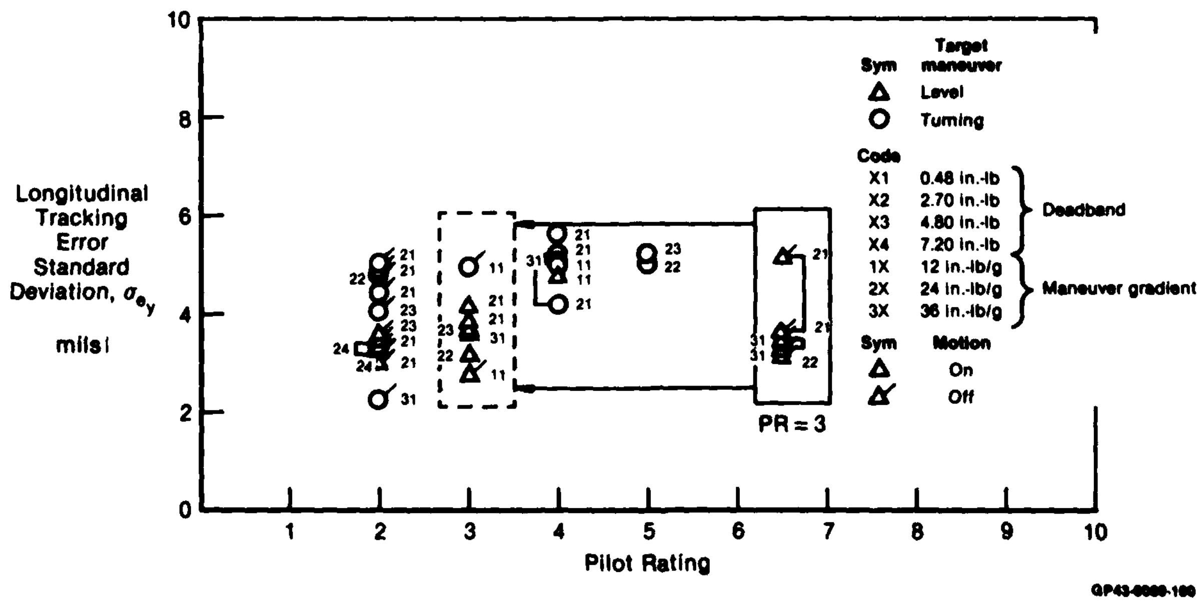


Figure 114. Longitudinal Tracking Error vs Pilot Rating
Twist Grip Sidestick Wings Level Turn Pilot 22

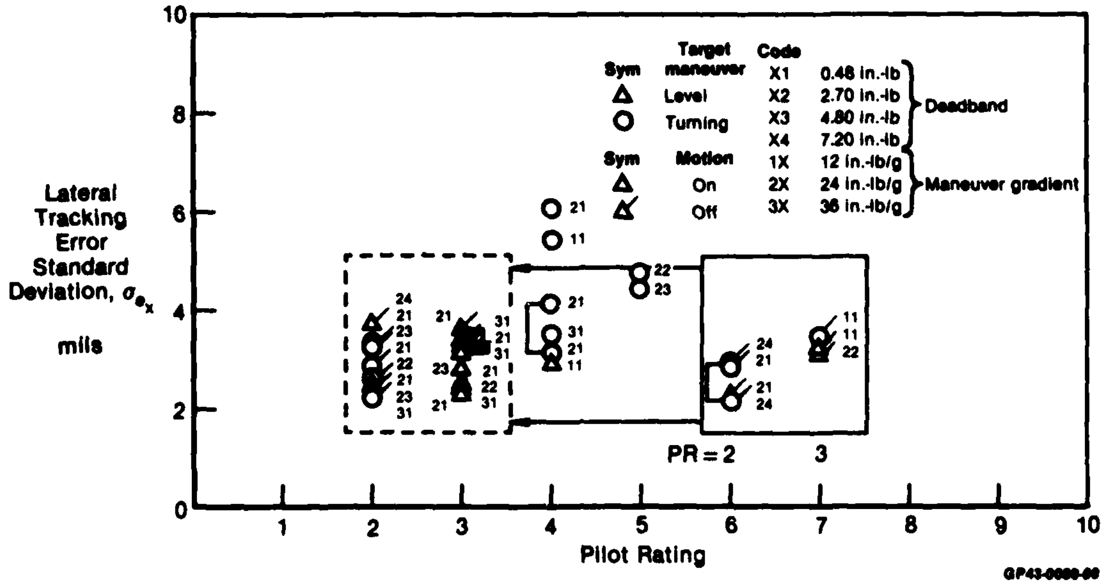


Figure 115. Lateral Tracking Error vs Pilot Rating
Twist Grip Sidestick Wings Level Turn Pilot 22

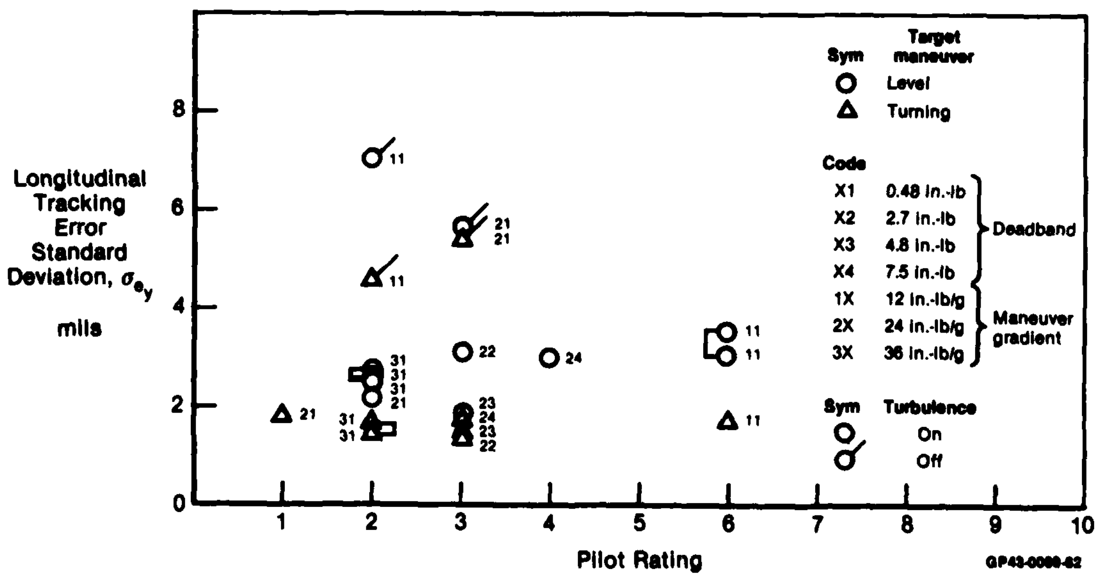


Figure 116. Longitudinal Tracking Error vs Pilot Rating
Twist Grip Sidestick Wings Level Turn Pilot 23

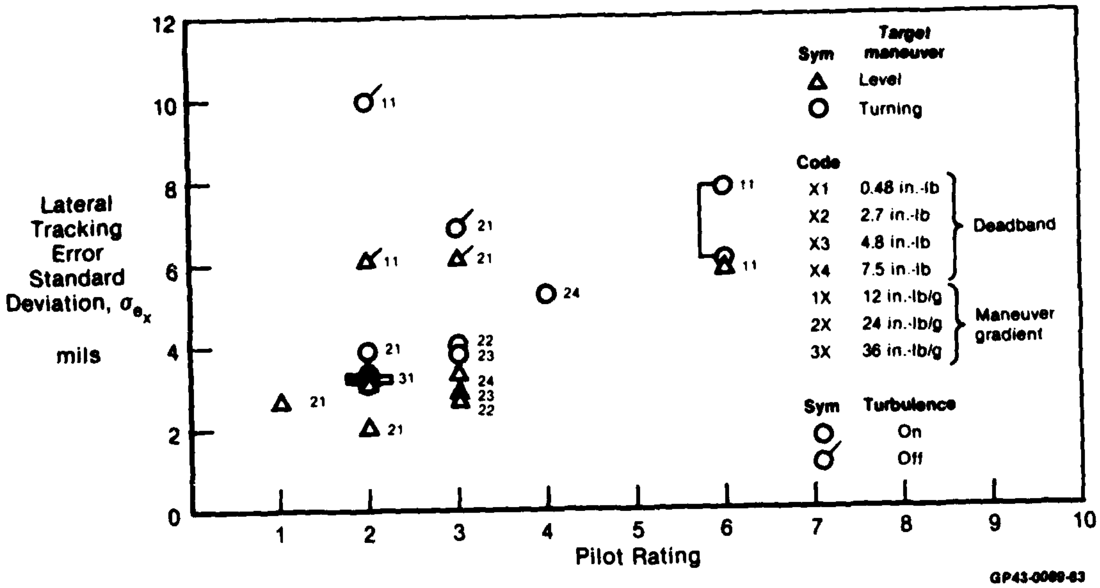


Figure 117. Lateral Tracking Error vs Pilot Rating
Twist Grip Sidestick Wings Level Turn Pilot 23

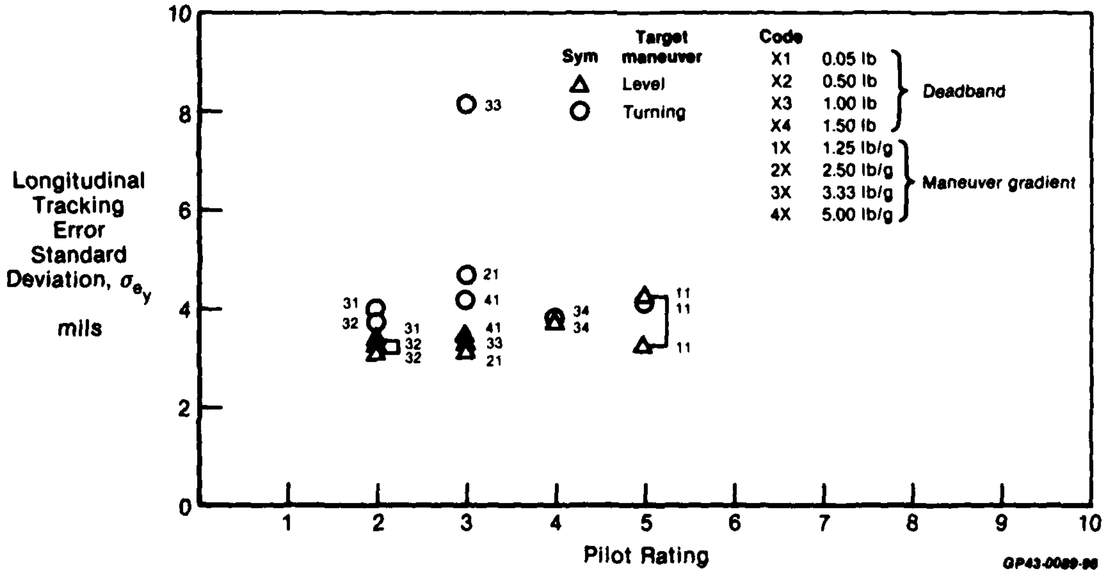


Figure 118. Longitudinal Tracking Error vs Pilot Rating
Thumb Button Controller Wings Level Turn Pilot 21

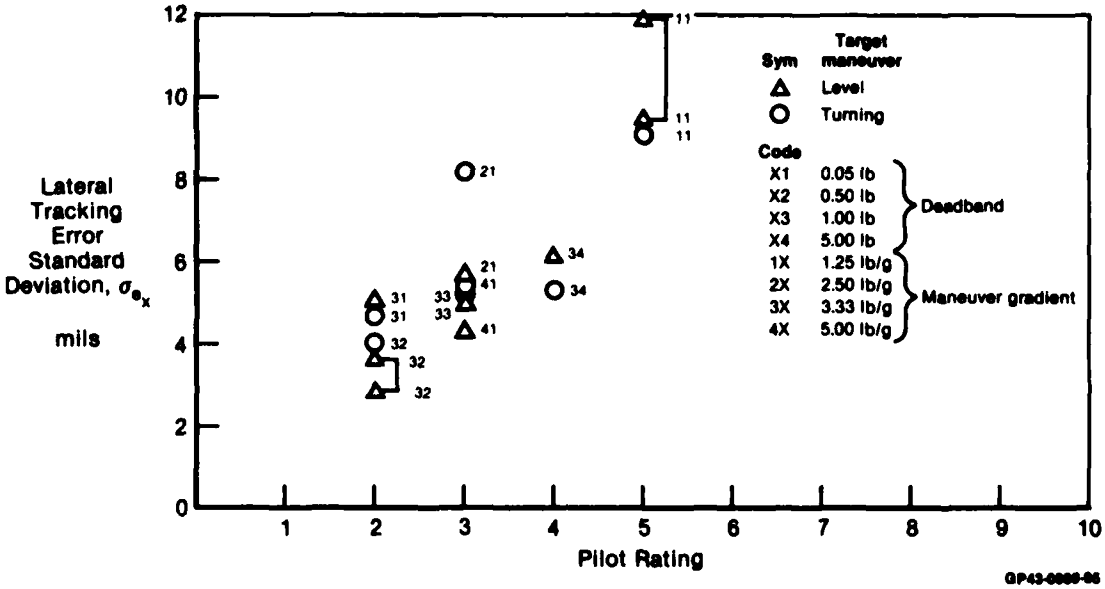


Figure 119. Lateral Tracking Error vs Pilot Rating
Thumb Button Controller   Wings Level Turn   Pilot 21

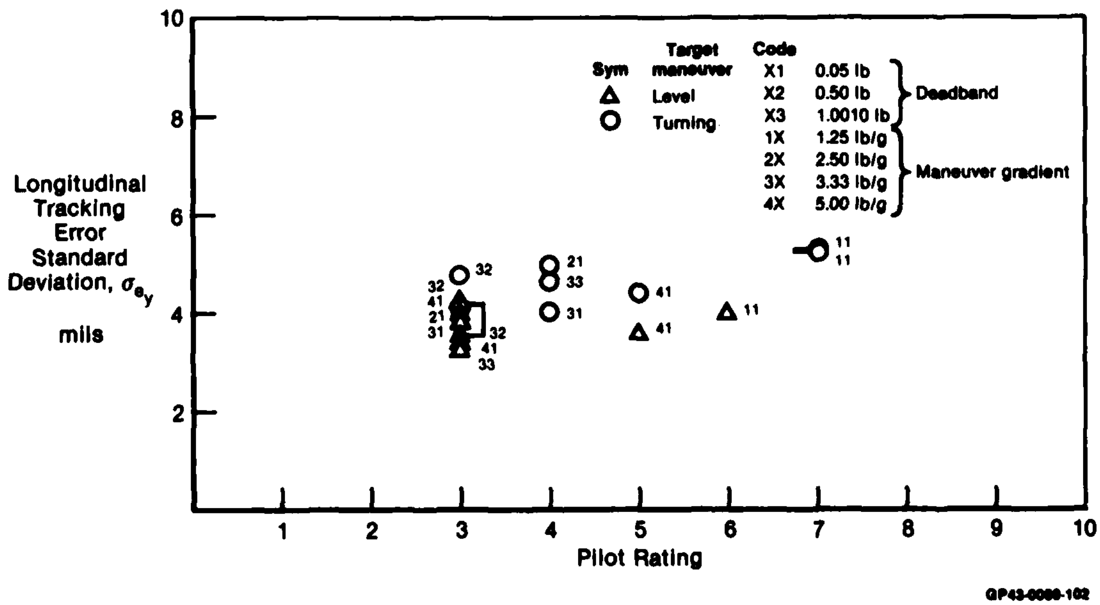


Figure 120. Longitudinal Tracking Error vs Pilot Rating
Thumb Button Controller   Wings Level Turn   Pilot 22

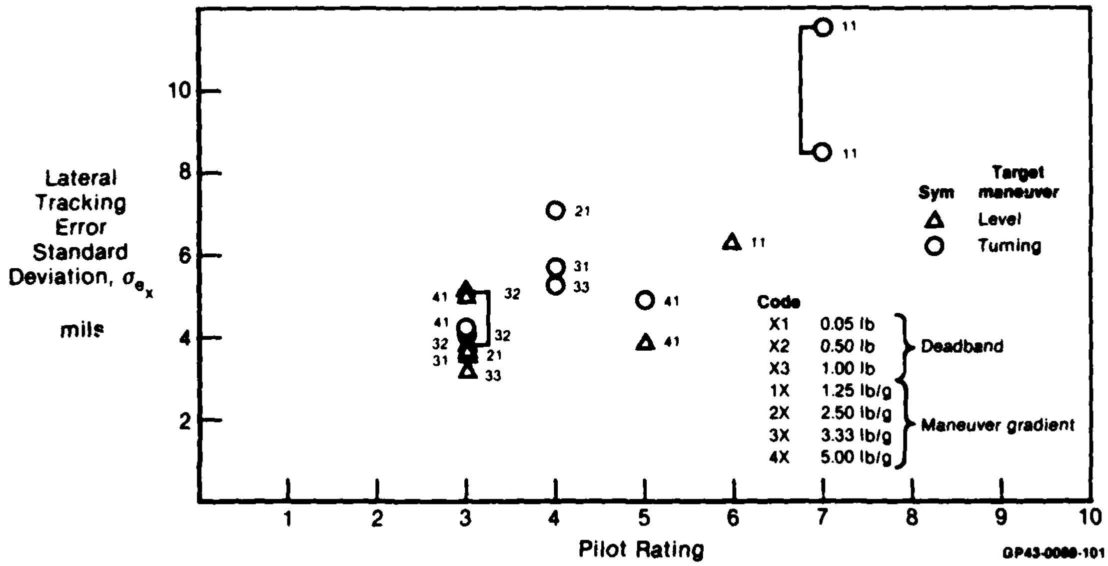


Figure 121. Lateral Tracking Error vs Pilot Rating
Thumb Button Controller Wings Level Turn Pilot 22

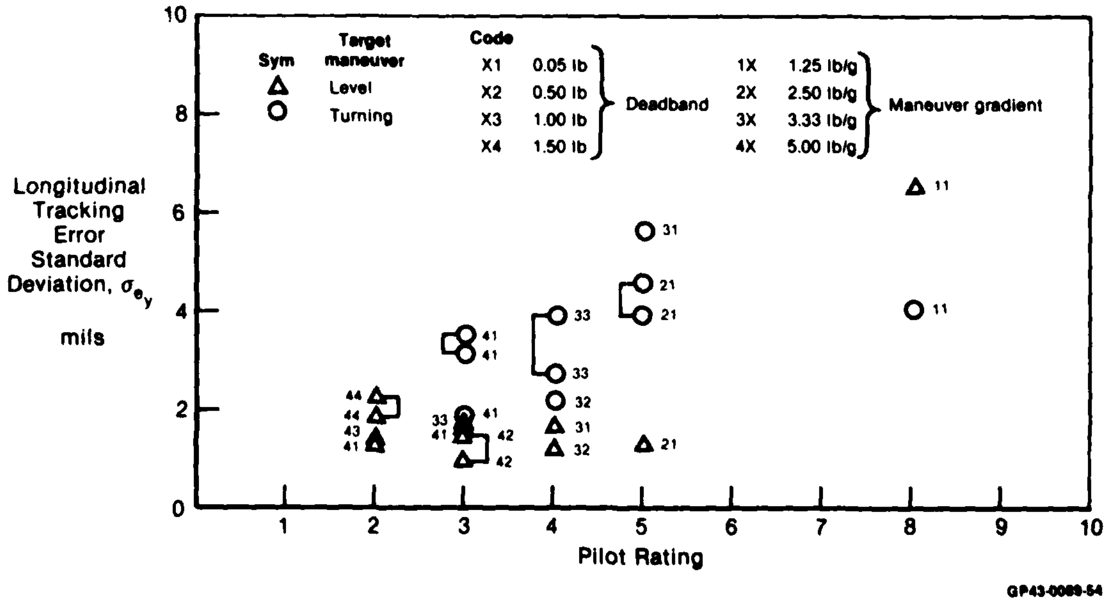


Figure 122. Longitudinal Tracking Error vs Pilot Rating
Thumb Button Controller Wings Level Turn Pilot 23

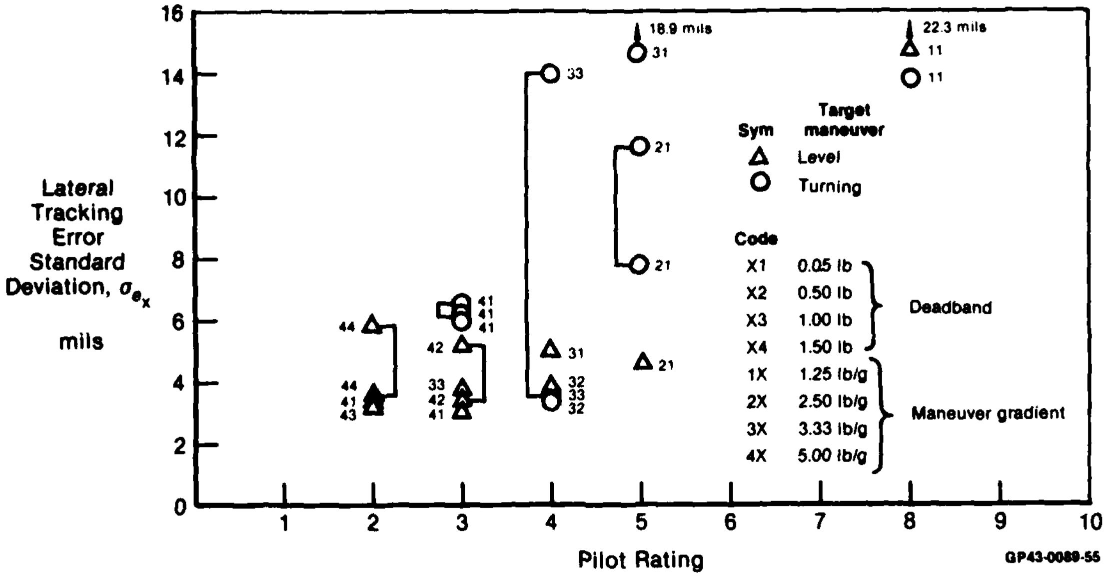


Figure 123. Lateral Tracking Error vs Pilot Rating
Thumb Button Controller Wings Level Turn Pilot 23

While the difference between best and worst error tends to increase with increasing numerical pilot rating, in general there are no strong trends in pipper error with pilot rating. Additionally, the longitudinal error showed little variation with pilot rating. These results tend to indicate that it would be difficult to evaluate configurations based on performance data alone.

It is interesting to note that for each pilot there is little change in lateral error scores for each of the controllers. It appears that the pilots could achieve equal quality results with all the controllers.

d. Comparisons - This section compares pilot rating results from evaluations in several types of environments. Pilots 22 and 23 had flown the air-to-ground evaluations using the wings level turn mode. These ratings are compared to those gathered during the air-to-air simulation. The failure of the motion drive system during the air-to-air simulation prompted an examination of the effects of the motion system on pilot rating and pilot performance. While collecting data for the frequency domain analysis of the next section, Pilot 21 repeated his earlier air-to-air evaluations in the presence of atmospheric turbulence and motion system disturbances. While it was not the primary purpose, these runs do allow us to examine the effect of motion disturbances on Pilot 21's ratings and pipper error performance.

(1) Comparison of Air-to-Air and Air-to-Ground Pilot Rating Results - Both Pilot 22 and 23 had participated in the air-to-ground simulation and were identified as Pilots 7 and 2 respectively. Before comparing the ratings, a brief discussion of differences in the two tasks would be appropriate. The air-to-air tasks required less than full wings level turn authority to accomplish. The target aircraft was constantly changing bank angle, requiring the pilot to make constantly changing inputs to follow the target. Additionally, the roll coupling applied by the pilot was in a favorable direction since the pilot was tracking a banking target. In the air-to-ground evaluations the pilots would roll out, acquire the first target, shoot, and transition to the second target. The acquisition of the first target and the transition to the second target were often done by application of quick, high-authority wings level turn commands. Thus pilot inputs for the air-to-ground tasks were generally more severe than for the air-to-air tasks. Additionally, even though roll coupling inadvertently applied by the pilot was in a favorable direction, the coupling greatly increased the difficulty of stabilizing on the second air-to-ground target.

Figures 124, 125 and 126 compare maneuver gradient variation performed by Pilot 22 using the 2 inch rudder pedals, twist grip sidestick and the thumb button controller. Figure 127 compares deadband variations using the thumb button controller. Pilot 22 did not perform any breakout or deadband variations for the rudder pedals or twist grip in the air-to-ground evaluations. In these plots data is presented for both the level and turning air-to-air tasks as well as the air-to-ground pilot ratings. For the rudder pedals the turning target and air-to-ground pilot ratings are at similar levels. However, in the air-to-ground task the pilot appears to have a preference for maneuver gradients of 60 lb/g and higher. The results for all tasks using the twist grip compare fairly well, with the turning target tasks receiving the poorest ratings. The thumb button was Pilot 22's least liked controller. The apparent reversal in trend shown in Figure 126 for the air-to-ground data is felt to be related to the previously mentioned difference in task. At the higher maneuver gradient in the air-to-ground task, the pilot experienced severe coupling problems.

Due to the differences in preferred maneuver gradient, it is doubtful that any strong statements can be made about the comparison of deadband variations shown in Figure 127. This problem is compounded by the limited range of deadbands examined by Pilot 22 in the air-to-ground evaluations.

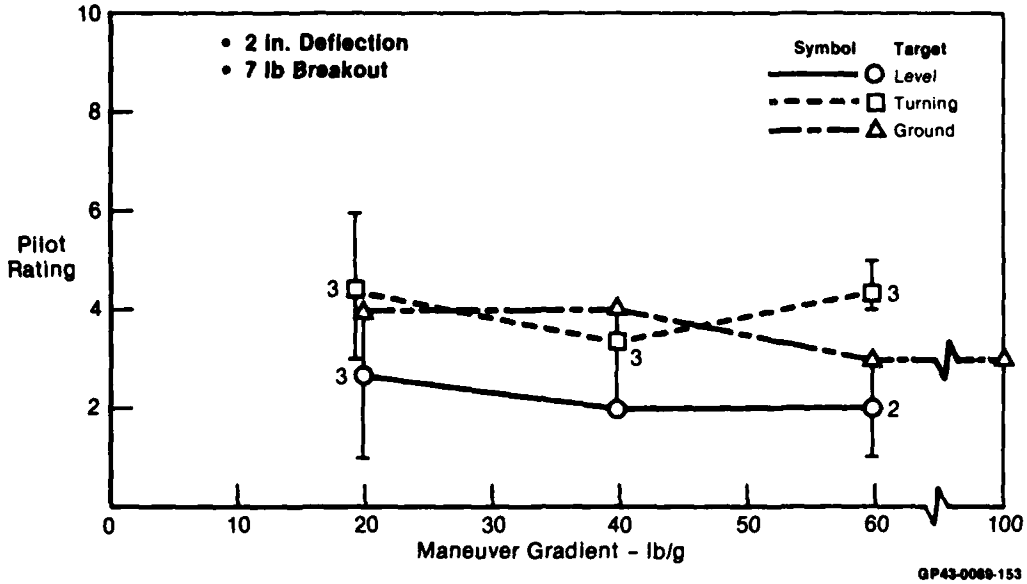


Figure 124. Pilot Rating vs Maneuver Gradient
Rudder Pedals Wings Level Turn Pilot 22

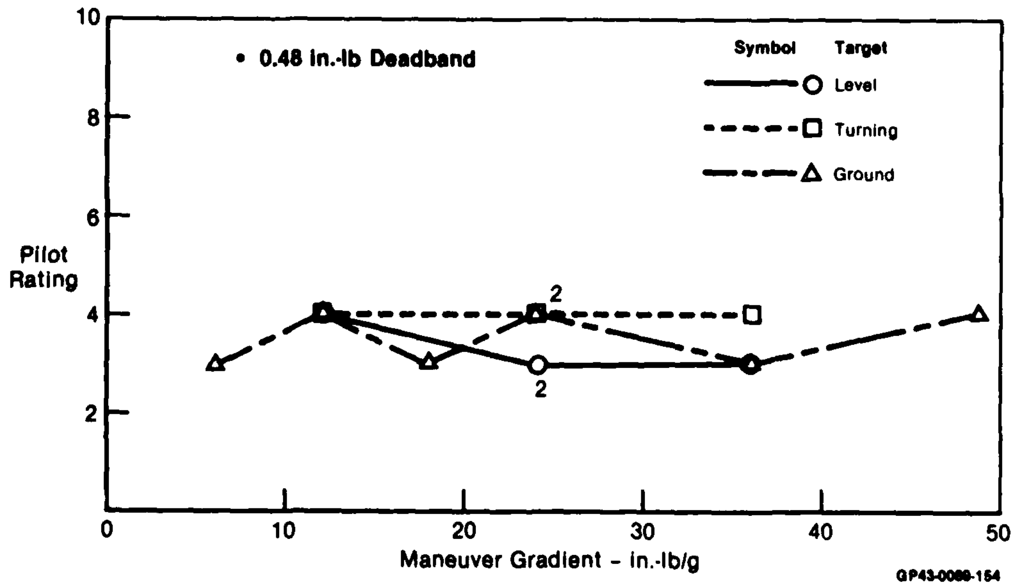


Figure 125. Pilot Rating vs Maneuver Gradient
Twist Grip Sidestick Wings Level Turn Pilot 22

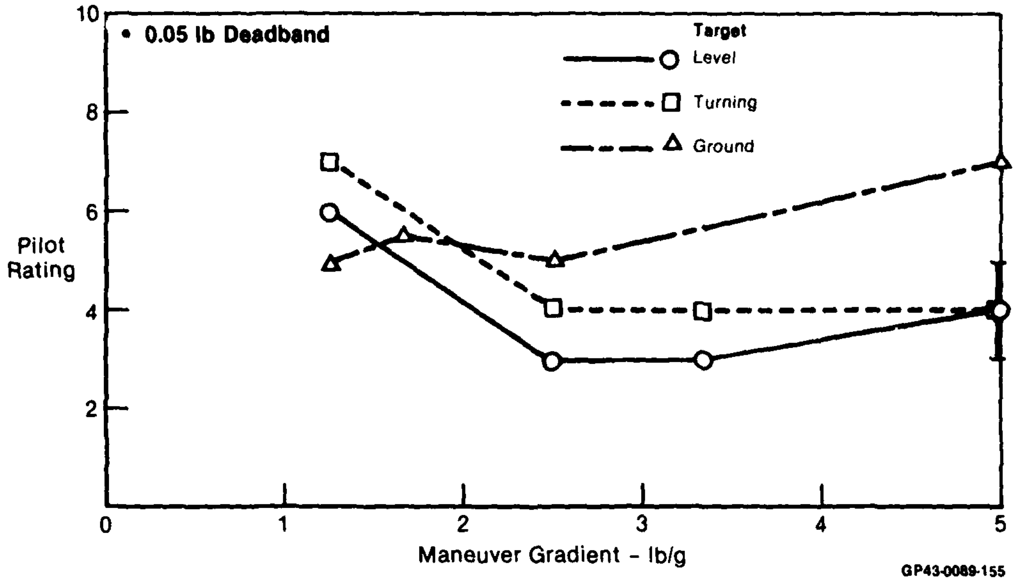


Figure 126. Pilot Rating vs Maneuver Gradient
Thumb Button Controller Wings Level Turn Pilot 22

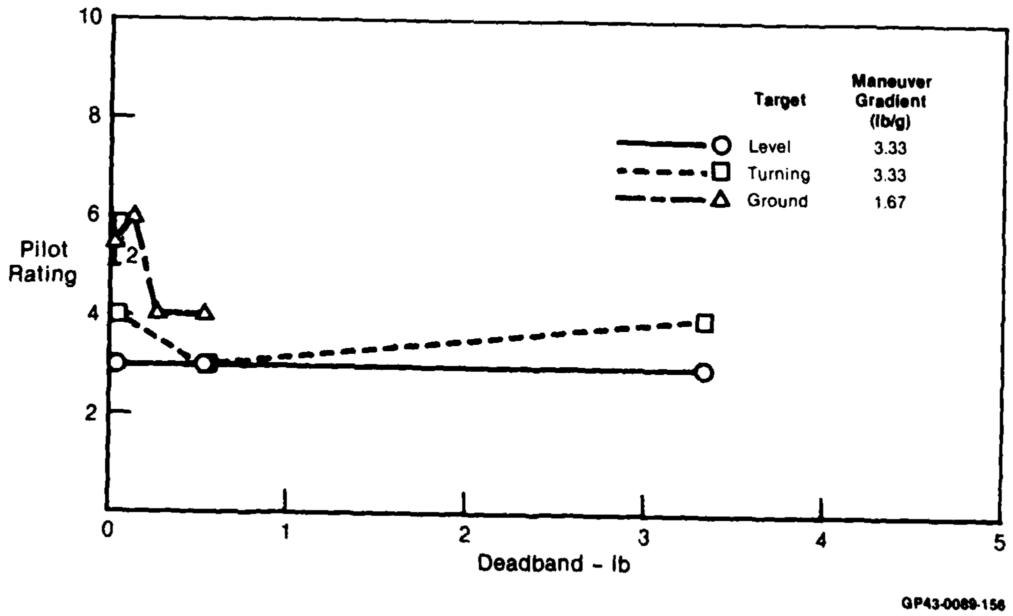


Figure 127. Pilot Rating vs Deadband
Thumb Button Controller Wings Level Turn Pilot 22

Figure 128 compares the Pilot 23 ratings for the maneuver gradient variation on rudder pedals in the air-to-air and felt that the CH=4 of the 60 lb/g for the air-to-ground ratings is inconsistent with the CH=2 at the 40 and 100 lb/g levels. In general, the pilot did not appear to be very sensitive to maneuver gradient in the air-to-ground environment. The reader is referred to the air-to-air rating discussion for detailed comments concerning Pilot 23's size and use of the rudder pedals. Pilot 23 did not perform a breakout variation in the air-to-ground tasks.

The results of the maneuver gradient and deadband variation for Pilot 23 using the twist grip sidestick are shown in Figures 129 and 130. The trends in both variations are similar regardless of task. However, in the air-to-ground tasks the pilot seems to be less sensitive to variations in maneuver gradient and somewhat more sensitive to variations in deadband. These results are felt to be consistent with the differences in the air-to-air and air-to-ground tasks. For instance, at a deadband of 4.8 in-lb in the air-to-ground tasks the pilot comments indicate that the major problem was coupling of twist axis inputs into other control axes. These types of comments were not noted in the air-to-air evaluations.

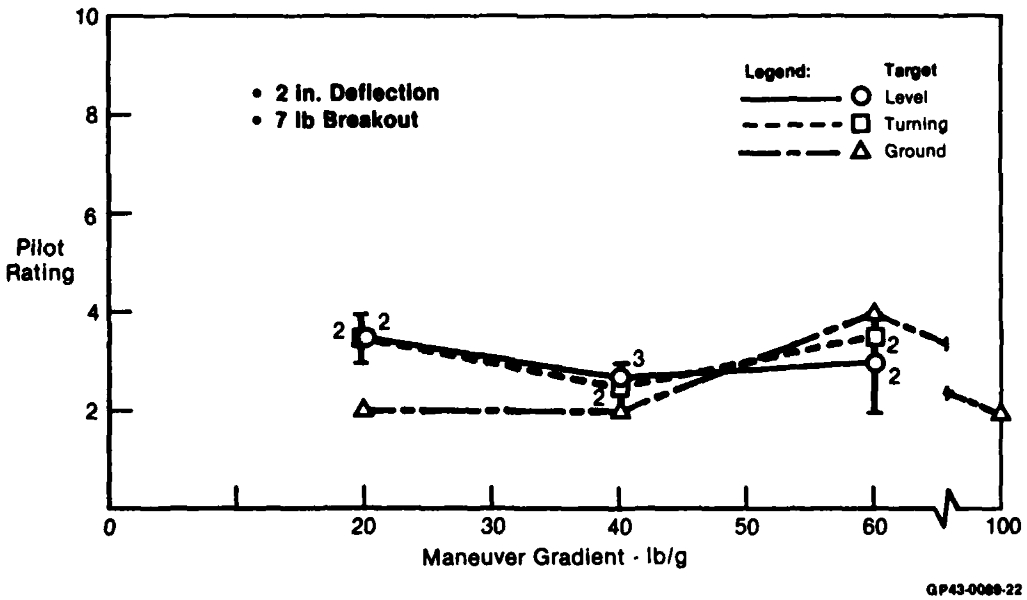


Figure 128. Pilot Rating vs Maneuver Gradient
Rudder Pedal Wings Level Turn Pilot 23

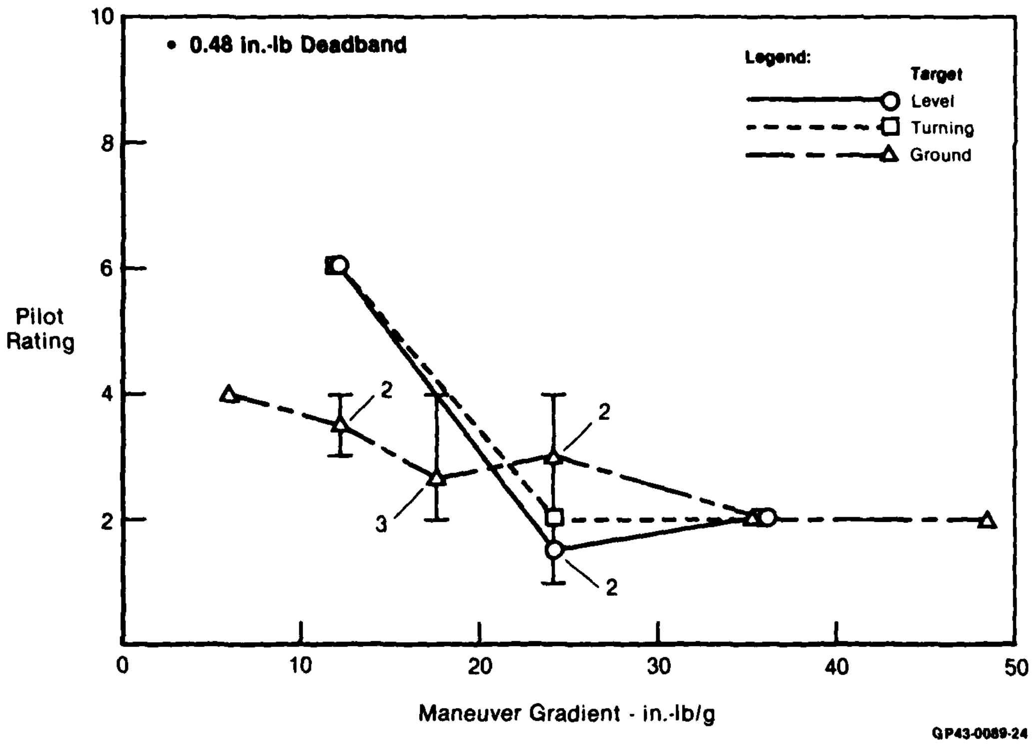


Figure 129. Pilot Rating vs Maneuver Gradient
Twist Grip Sidestick Wings Level Turn Pilot 23

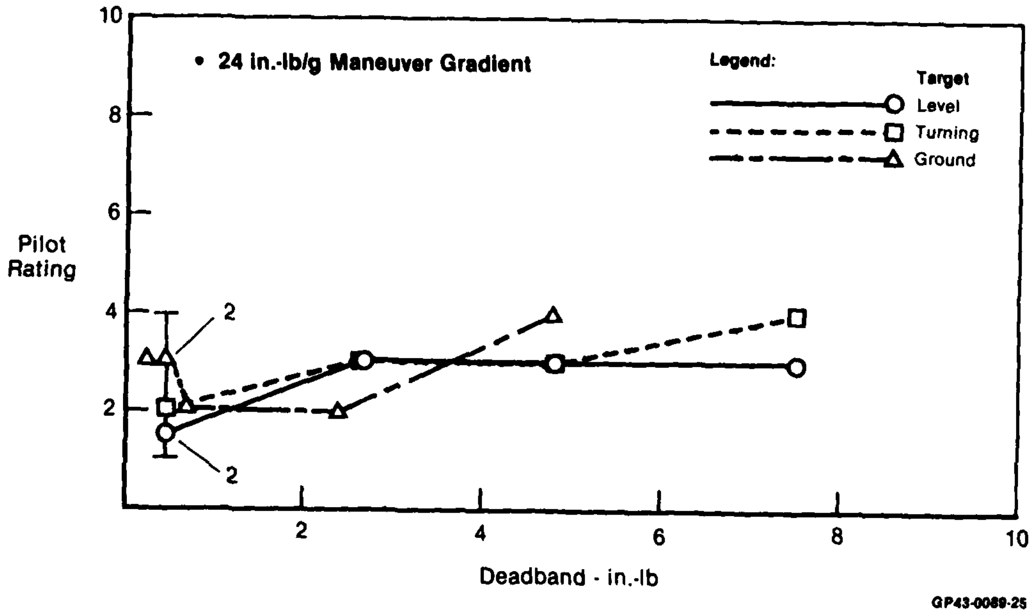


Figure 130. Pilot Rating vs Deadband
Twist Grip Sidestick Wings Level Turn Pilot 23

Figure 131 indicates the same trend in preferred thumb button maneuver gradient for Pilot 23 as was noted for Pilot 22. However, Pilot 23 found the button to be more acceptable in the air-to-ground tasks than did Pilot 22. The difference in rating for the lighter maneuver gradients shown in the figure is felt to be consistent with the sharp, high authority usage previously described for mode usage in the air-to-ground tasks.

(2) Comparison of Fixed-Base and Motion-Base Pilot Ratings - During the first session of the air-to-air simulation, a hydraulic pump failure in the motion system forced a decision whether to carry on in the fixed base mode or wait for the pump to be repaired. In order to gather data to assist in making this decision, two fixed-base testing sessions were used to repeat configurations and tasks previously examined with motion. The twist grip sidestick controller was selected for re-evaluation because it seemed the controller most sensitive to motion effects based on engineering and pilot opinion. The pilot rating versus controller variation for both pilots are shown in Figure 132 through 135.

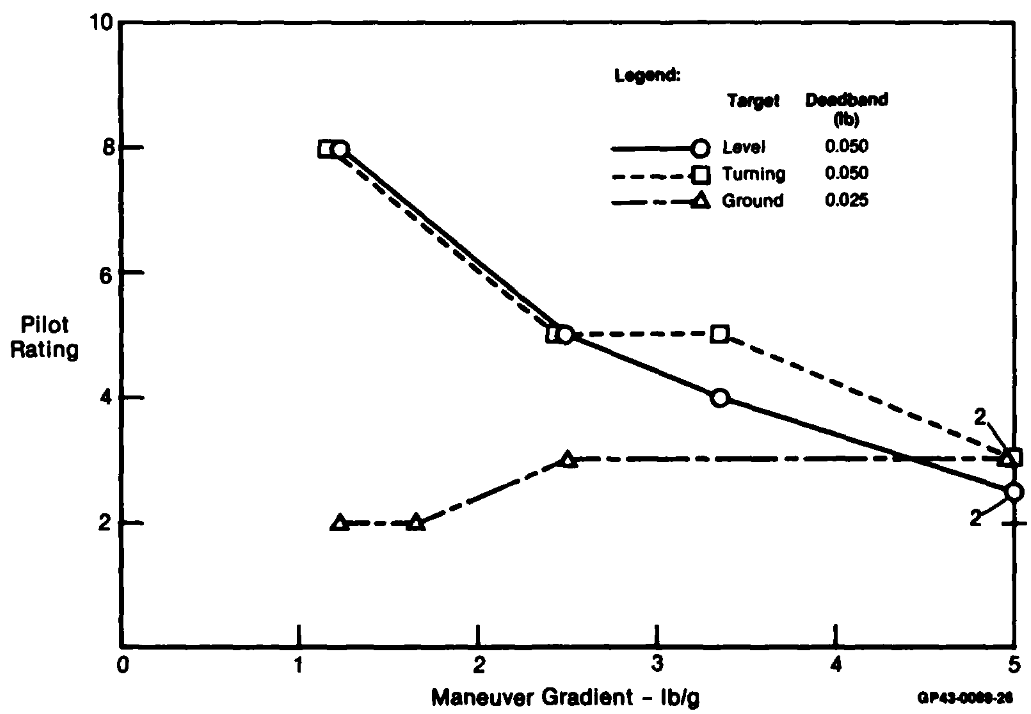


Figure 131. Pilot Rating vs Maneuver Gradient
Thumb Button Controller Wings Level Turn Pilot 23

Figure 132 shows the variation in pilot rating with maneuver gradient for Pilot 21 both with and without motion. No change in ratings were noted for the level target task. For the turning target variations do exist but no clear meaning can be identified. In Figure 133 the differences become apparent. There is a much more severe degradation in pilot rating with increasing deadband for the evaluations with motion.

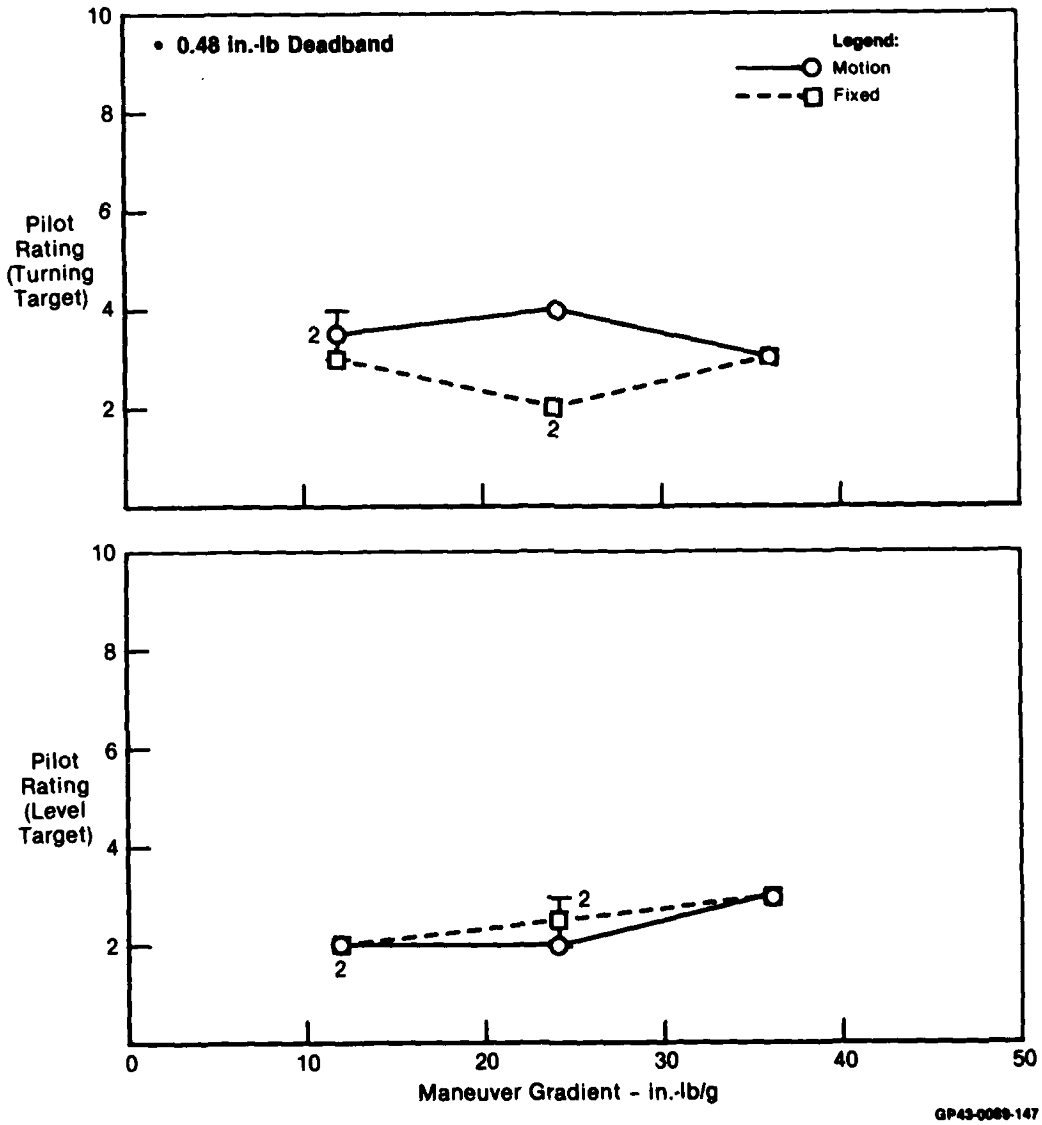


Figure 132. Effect of Motion on Pilot Rating - Maneuver Gradient
Twist Grip Sidestick Wings Level Turn Pilot 21

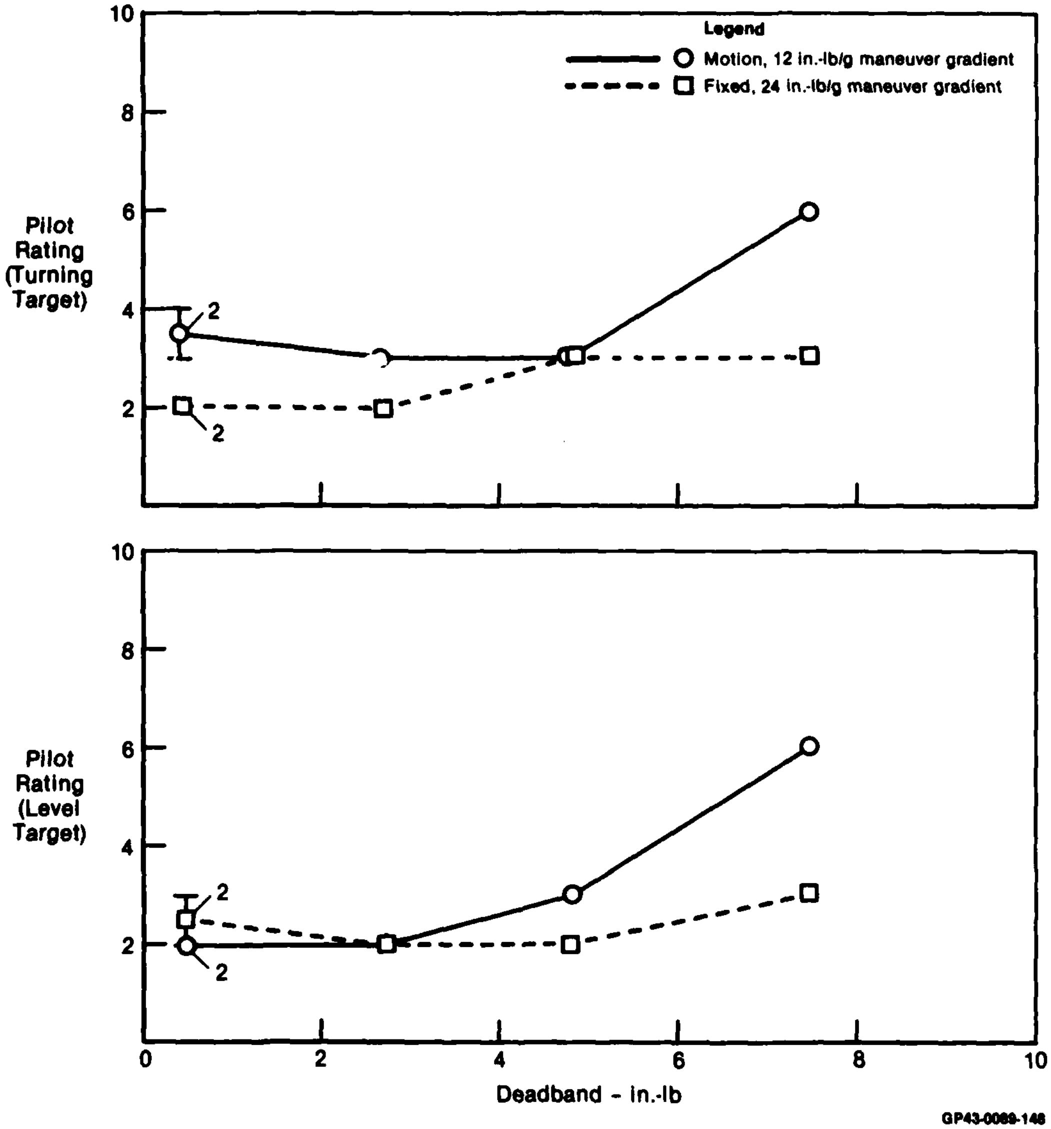


Figure 133. Effect of Motion on Pilot Rating - Deadband
Twist Grip Sidestick   Wings Level Turn   Pilot 21

The data for Pilot 22, Figures 134 and 135, do not display the same trends, however, definite differences do exist for the turning target tasks. It is evident from the data in Figure 134 and 135 that the turning tasks exhibited degraded pilot ratings for the motion tests as compared to the fixed base evaluations.

These plots show a significant difference for motion and fixed base pilot ratings. Pilot 21 commented that he felt the tasks were definitely easier without motion. Pilot 22 on the other hand felt that the lack of motion cues would not be a problem. After the fixed base evaluations, both pilots commented that the differences between configurations were hard to identify.

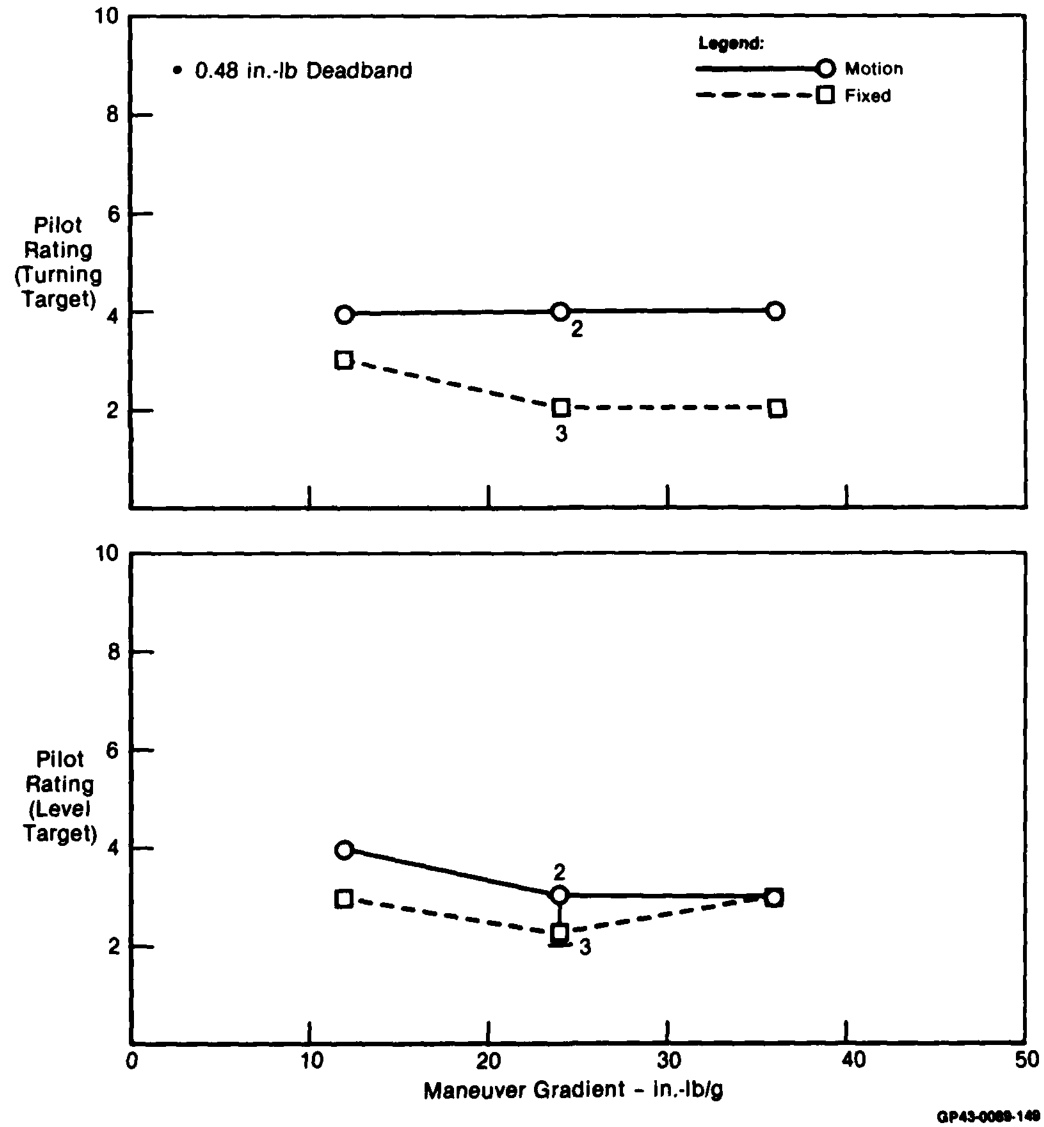


Figure 134. Effect of Motion on Pilot Rating - Maneuver Gradient
Twist Grip Sidestick Wings Level Turn Pilot 22

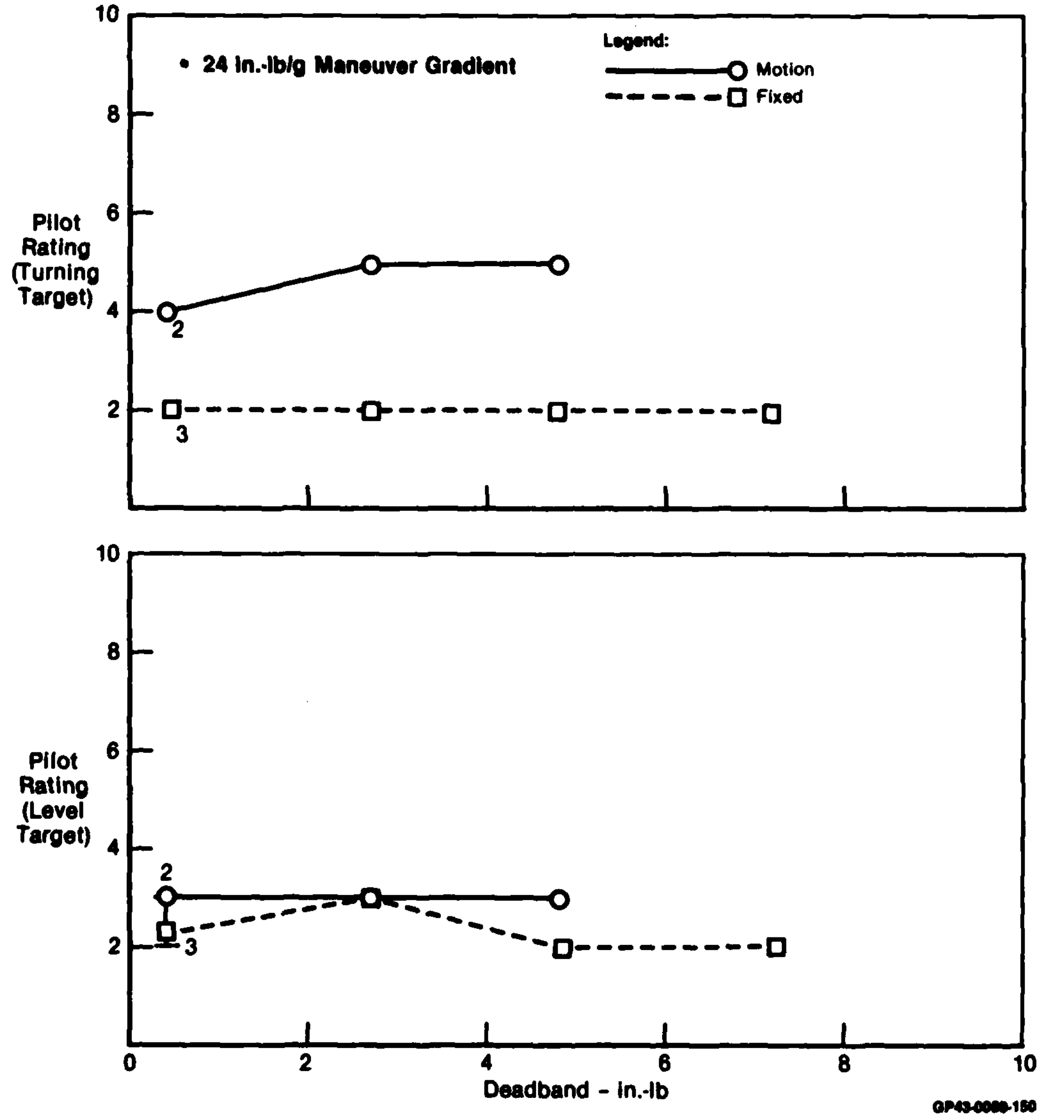


Figure 135. Effect of Motion on Pilot Rating - Deadband
Twist Grip Sidestick Wings Level Turn Pilot 22

While there is a strong tendency to state that these differences are due only to the presence or lack of motion, other factors must be considered. The effects of motion system attenuation and washouts are not accounted for by this limited evaluation. Additionally, it is possible that pilot learning effects could be present since both pilots tested this controller earlier in the first week. However, the differences were great enough to cast doubt on the advisibility of continuing the evaluations fixed-base.

When the motion system was repaired, Pilot 21 repeated the twist grip sidestick evaluations again. The results are presented in Figures 136 and 137. A review of the maneuver gradient results of Figure 136 appear to indicate that these repeats were closer to the fixed base results than to the earlier motion based results. The results of the deadband variation, shown in Figure 137, indicates that the pilots second session motion ratings are lower (i.e., better) than the first session motion just as the fixed base results were. However, if the amount of rating degradation is examined, (i.e., the ΔCH between the worst and best configurations) in the range of deadbands from .48 to 7.5 in-lb, the conclusions are slightly modified. For example, in the level target task, CH=4 for the first session motion, 1 for the first session fixed and 3 for the second session motion. Similarly, for the turning target tasks, the CH's are 3, 1, and 3 in going from first session motion to second session motion. Clearly, when compared in this fashion, the second session motion more closely resembles the first session motion results than the fixed base results. In addition, if one recalls the non-linear usage of the Cooper-Harper scale (see Section 12 introduction) the maximum CH=3 collected in the fixed base simulation further supports the benefits of the motion-based simulation. It may be possible that the differences in ratings between the two motion evaluations can be attributed to pilot learning effects.

(3) <u>Comparison of Pilot Ratings With and Without Turbulence</u> - Following the repeat of these motion based evaluation, Pilot 21 participated in an experiment to collect data for analysis of the effects of motion coupling. Much of Pilot 21's earlier air-to-air test matrix was duplicated with the addition of atmospheric turbulence and motion system disturbances. The wings level turn dynamics, tasks and controller configuration were the same as those used in the previous evaluations.

The motion system disturbances used during Pilot 21's evaluations were generated using sum-of-sines drive signals to the motion system heave and sideforce command paths. These sum-of-sines signals were the principal input for looking at motion coupling. The 3 ft/sec RMS atmospheric turbulence in pitch and yaw was used primarily to disguise the presence of the motion system disturbances. Pilot comments indicate that he was unaware of the motion system inputs which were uncorrelated with the

outside visual display. The motion system disturbances were of small amplitude and at frequencies higher than those of the target. The disturbances will be described in detail in the next section, dealing with results of the motion coupling experiment. For the purposes of this discussion it is sufficient to note that these disturbances were transparent to the pilot.

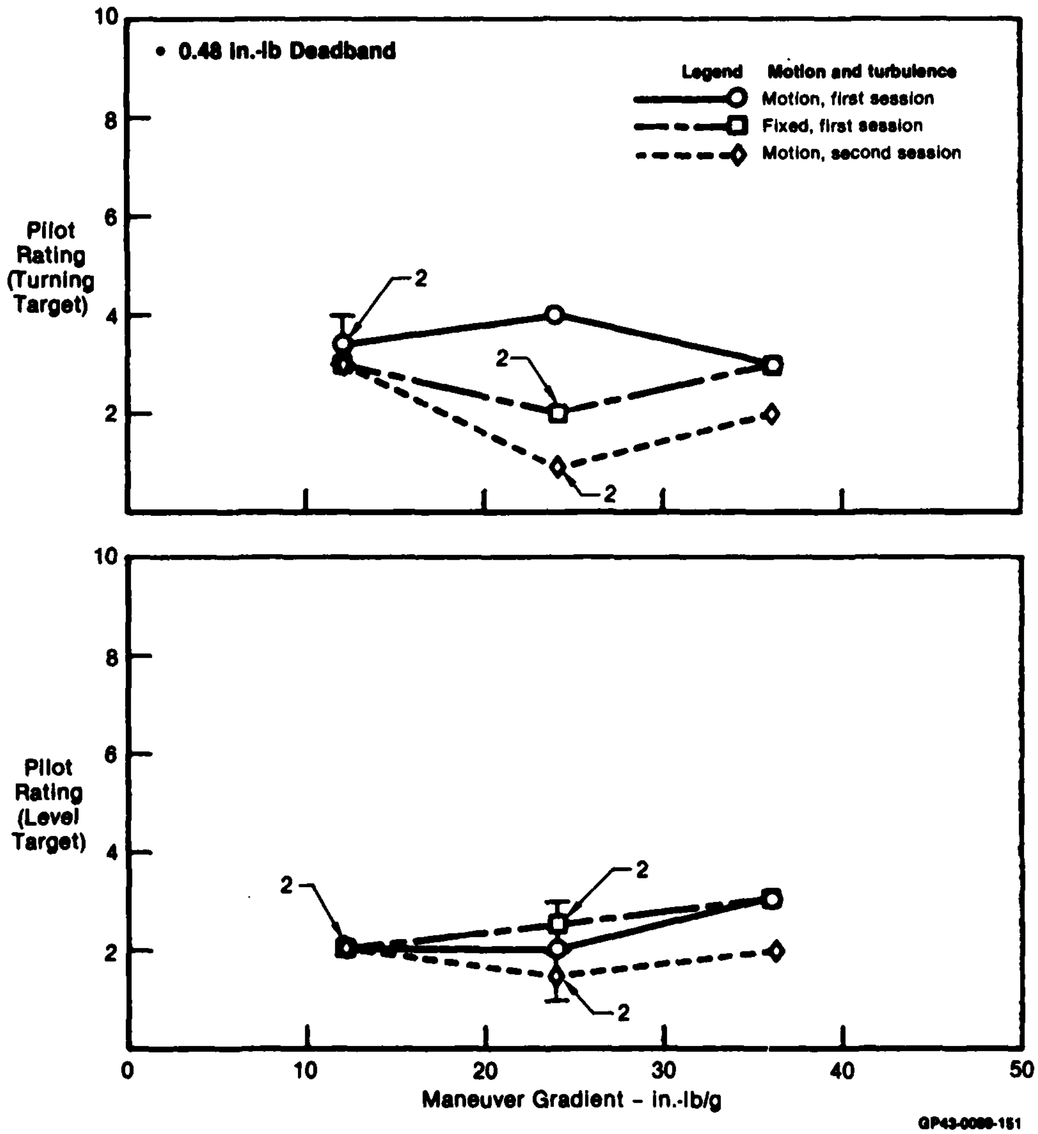


Figure 136. Effect of Motion on Pilot Rating - Maneuver Gradient
Twist Grip Sidestick Wings Level Turn Pilot 21

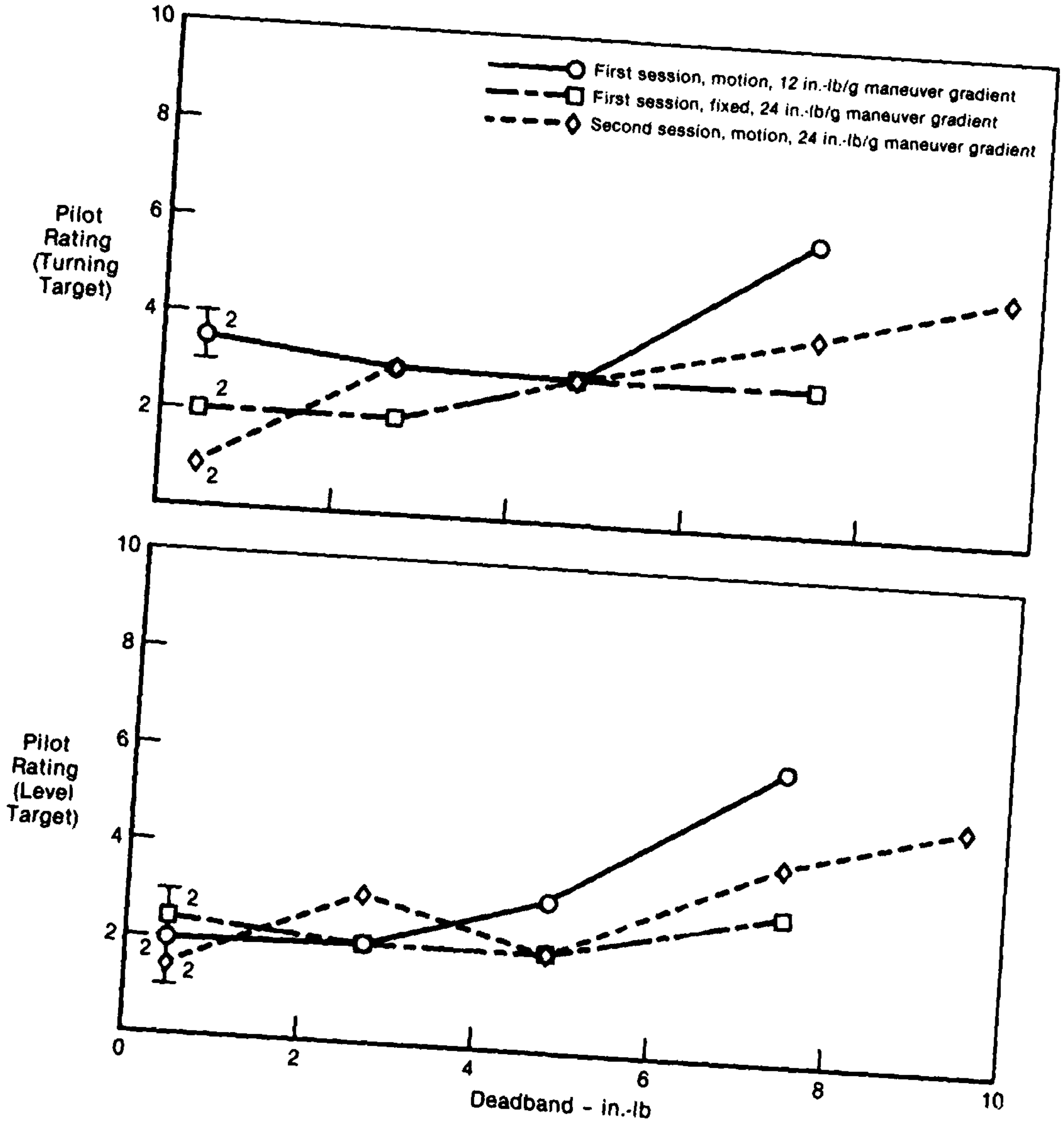


Figure 137. Effect of Motion on Pilot Rating - Deadband
Twist Grip Sidestick Wings Level Turn Pilot 21

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A secondary benefit of the motion coupling experiment is that it allowed comparison of Pilot 21's ratings with and without turbulence. These comparisons are shown in Figures 138 through 143. The ratings designated as no turbulence are from Pilot 21's evaluations during the first air-to-air. No motion disturbances or turbulence models were used during that simulation. The ratings designated "turbulence" are from the second air-to-air simulation and include the motion drive disturbances as well as the turbulence model. In general, the ratings and trends compare favorably. A few exceptions do need to be examined. In Figure 138 the initial turbulence ratings do not compare favorably with either the no turbulence or later turbulence evaluations. One possible explanation is that the first turbulence evaluations were the first few evaluations that day. While practice time was given prior to the evaluations, when using the pedals the pilots tended to feel they needed little warm-up time since it was a controller they were familiar with. The repeat turbulence evaluations were made the same day and are in much better agreement with the original, no turbulence, data. In Figure 143, the data points at the larger deadbands show significant difference between the first evaluations with turbulence and the other data.

It is significant to note that generally the ratings with turbulence do not differ significantly with the no turbulence ratings. In Figures 144 through 149 the longitudinal and lateral pipper error standard deviations for the turbulence-on evaluation are presented. Additionally, Figure 144 and 145 include turbulence off error data for the twist grip sidestick which was collected the same day as the turbulence on data. Note the significant increase in both longitudinal and lateral error. The pilot was aware of this increase due to his own observations and a decrease in the scores fedback to the pilot to encourage his participation. This leads to the question of why the pilot ratings with turbulence on were not significantly poorer than the turbulence off data. Two factors are believed to have influenced the pilots ratings. When comparing first simulation data to the turbulence-on ratings, pilot learning has probably had some influence on his perceptions of "goodness." Another factor which is felt to have influenced the ratings is the manner in which the pilots were asked to use the rating scale. The pilots were instructed to track the target as closely as possible, with no definite specification of desired or adequate performance. Scores of time within 5 and 10 mils of the target were then fed back to the pilots after they had established their rating. The ratings were to be determined by using the scale to establish a rating for the configuration in the task. In this case the turbulence was part of the task.

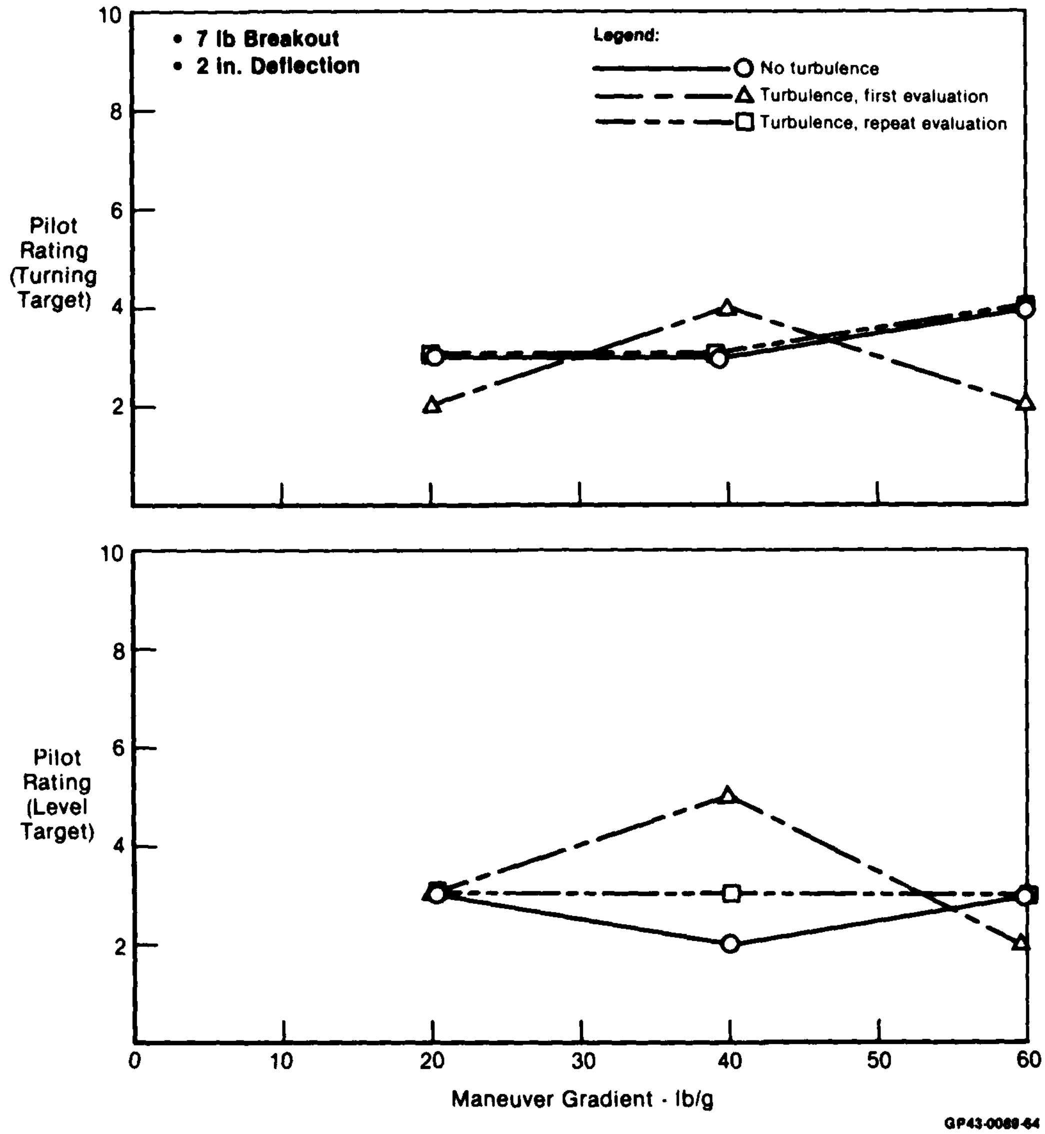

Figure 138. Pilot Rating vs Maneuver Gradient
Rudder Pedals Wings Level Turn Pilot 21

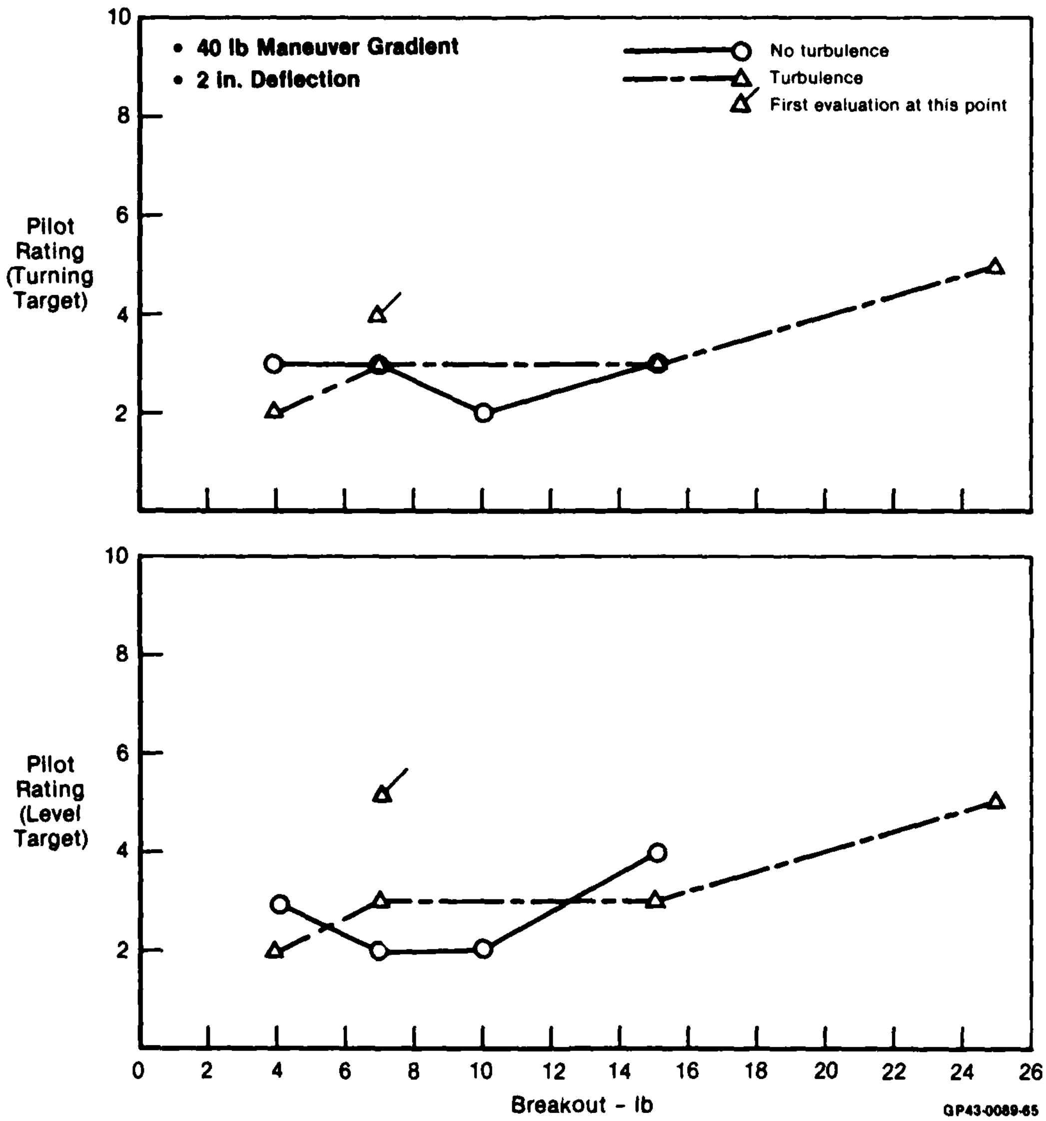

Figure 139. Pilot Rating vs Breakout
Rudder Pedals Wings Level Turn Pilot 21

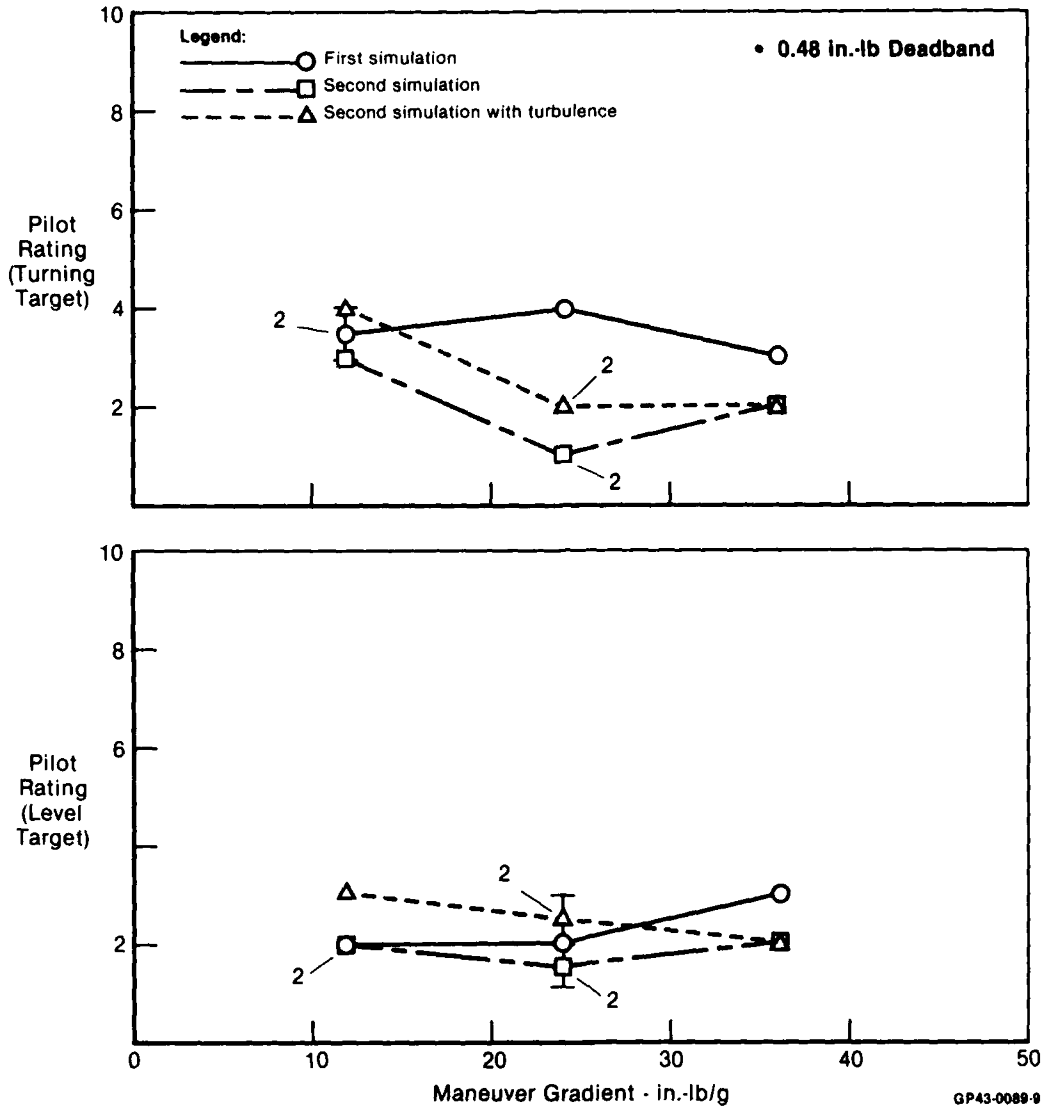

Figure 140. Pilot Rating vs Maneuver Gradient
Twist Grip Sidestick   Wings Level Turn   Pilot 21

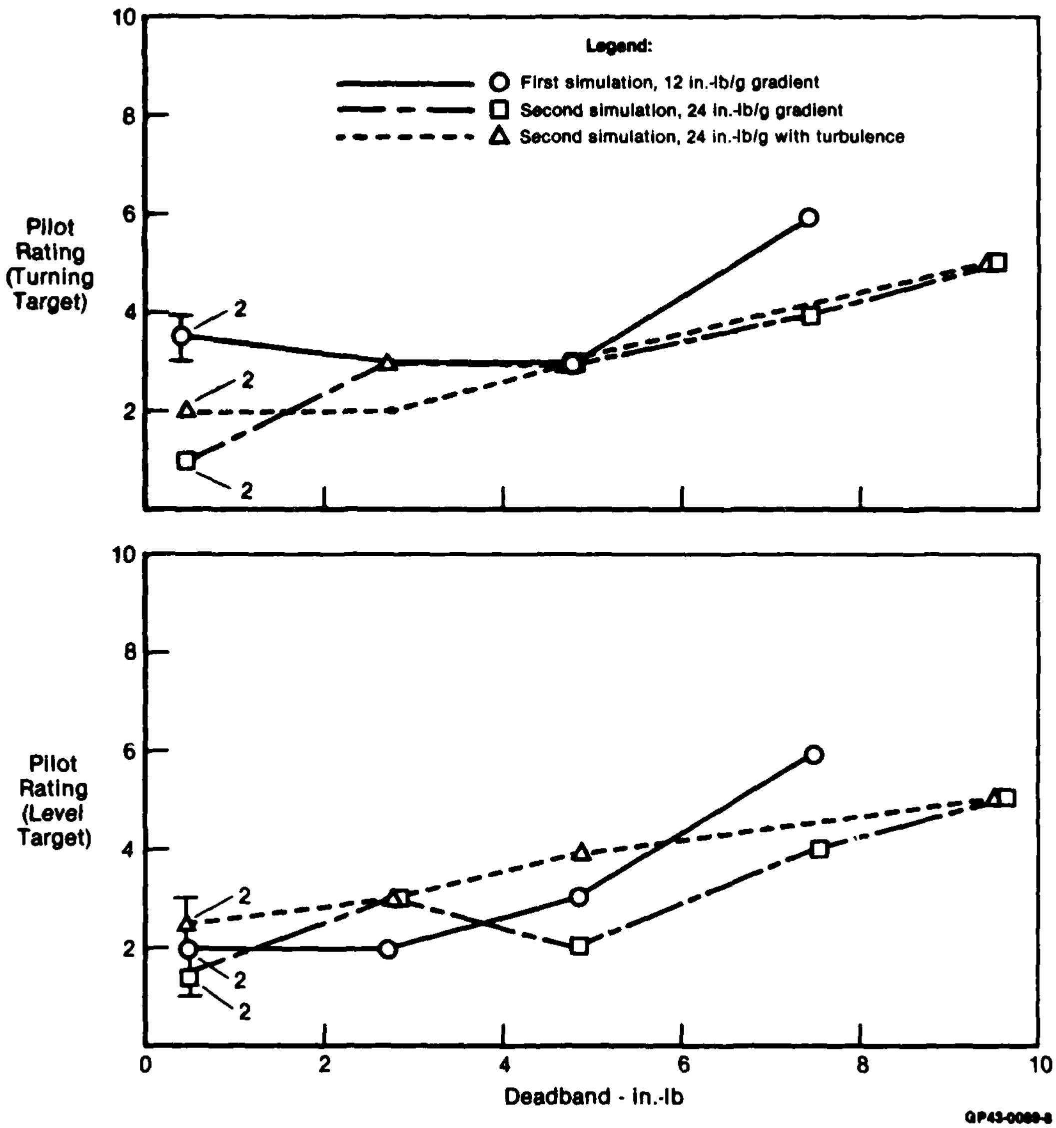

Figure 141. Pilot Rating vs Deadband
Twist Grip Sidestick   Wings Level Turn   Pilot 21

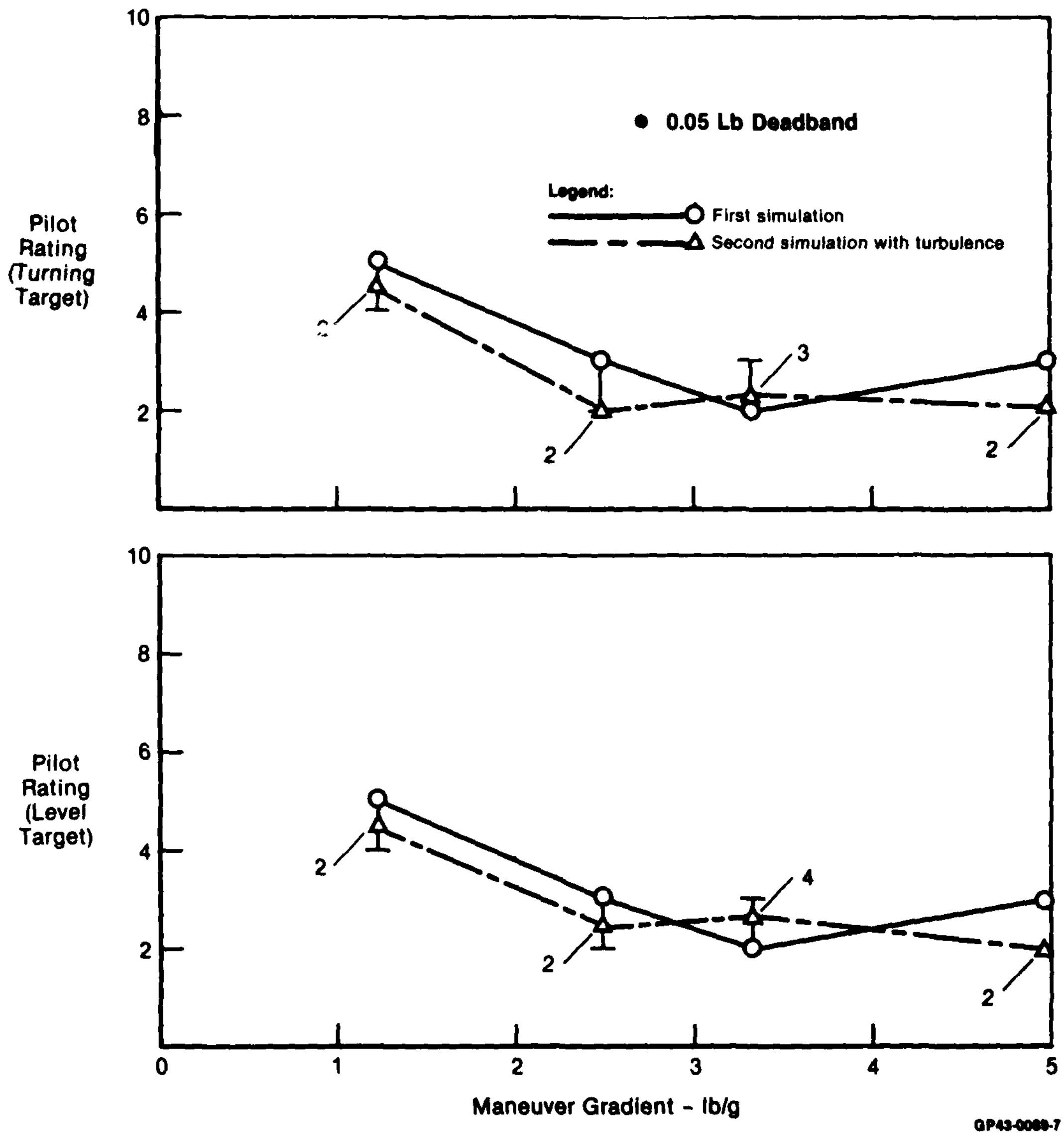

Figure 142. Pilot Rating vs Maneuver Gradient
Thumb Button Controller   Wings Level Turn   Pilot 21

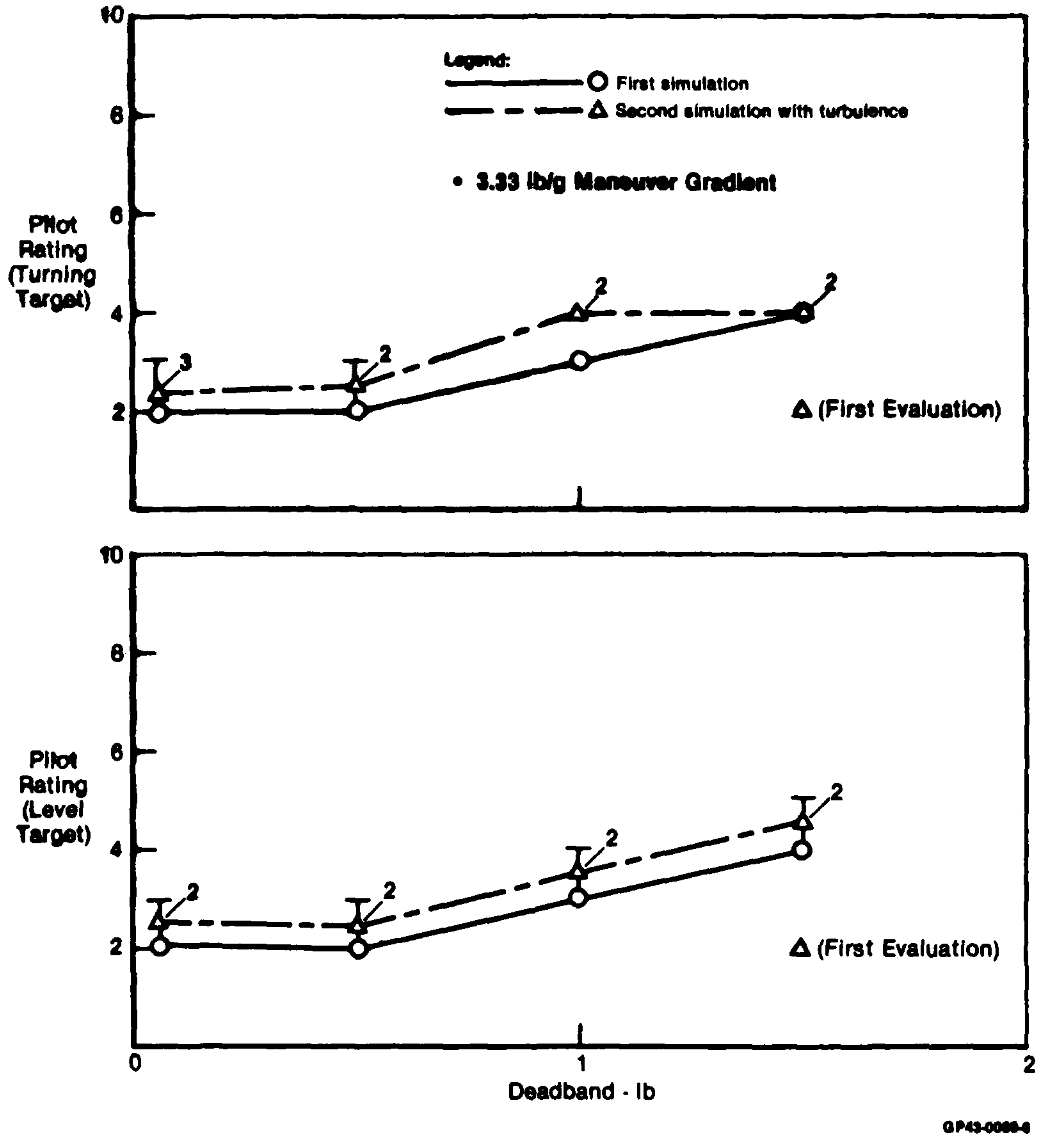

Figure 143. Pilot Rating vs Deadband
Thumb Button Controller Wings Level Turn Pilot 21

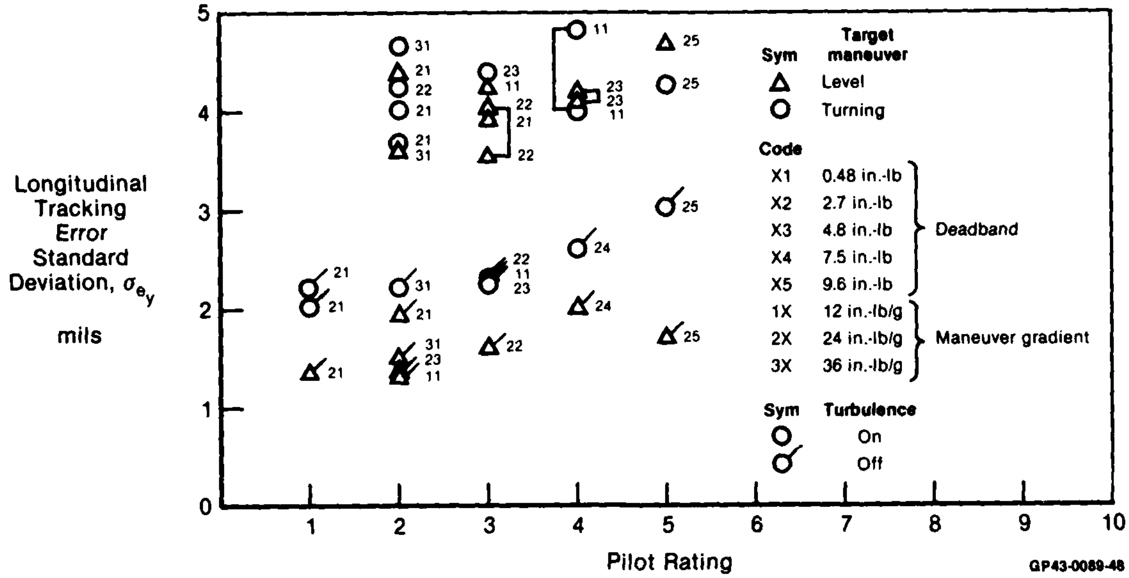

Figure 144. Longitudinal Tracking Error vs Pilot Rating
Twist Grip Sidestick Wings Level Turn Pilot 21

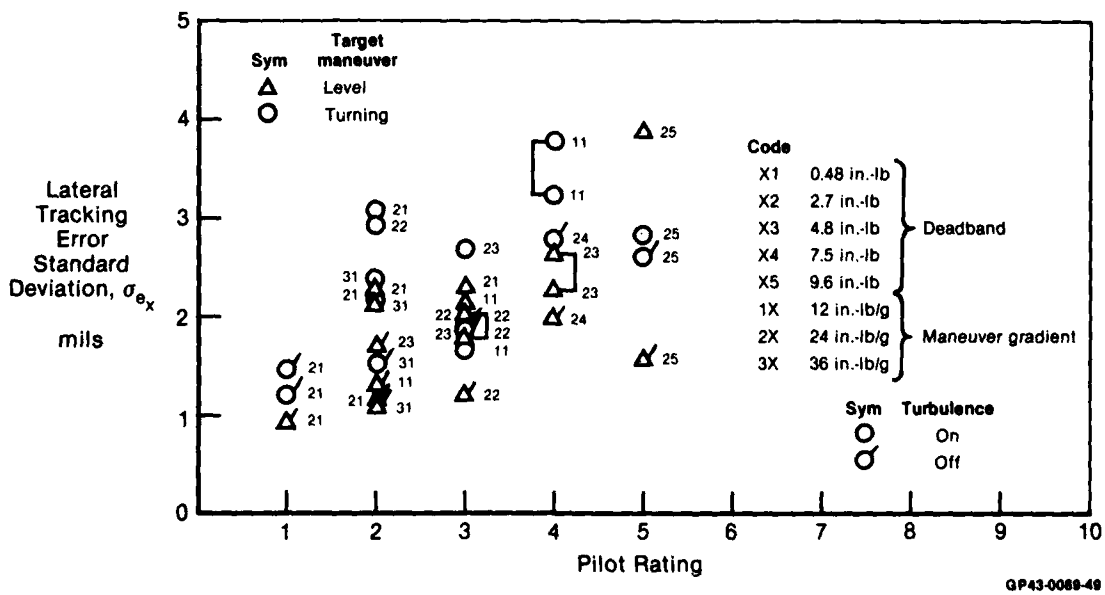

Figure 145. Lateral Tracking Error vs Pilot Rating
Twist Grip Sidestick Wings Level Turn Pilot 21

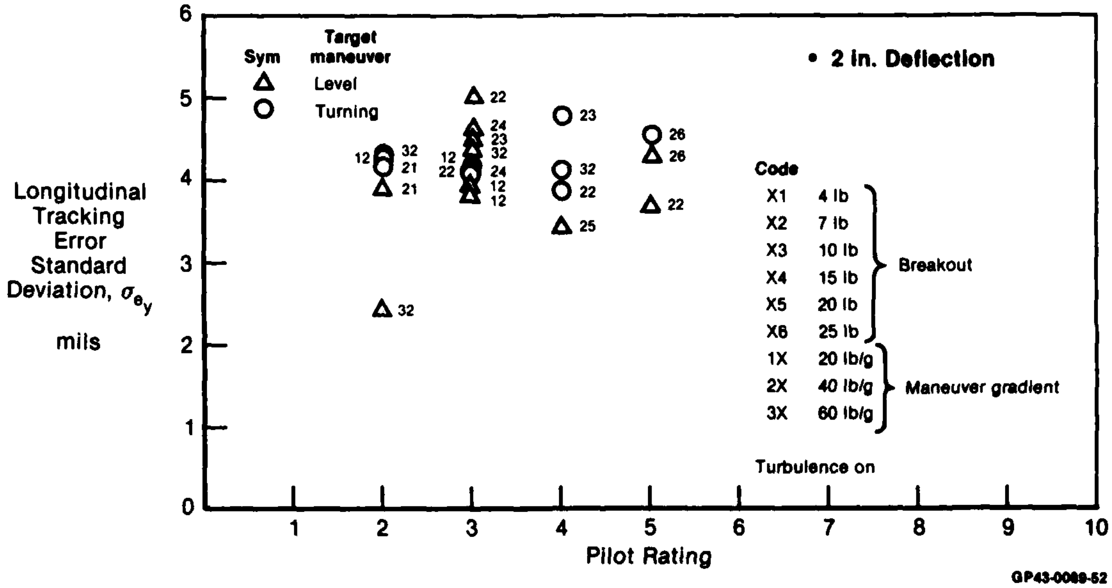

Figure 146. Longitudinal Tracking Error vs Pilot Rating
Rudder Pedals Wings Level Turn Pilot 21

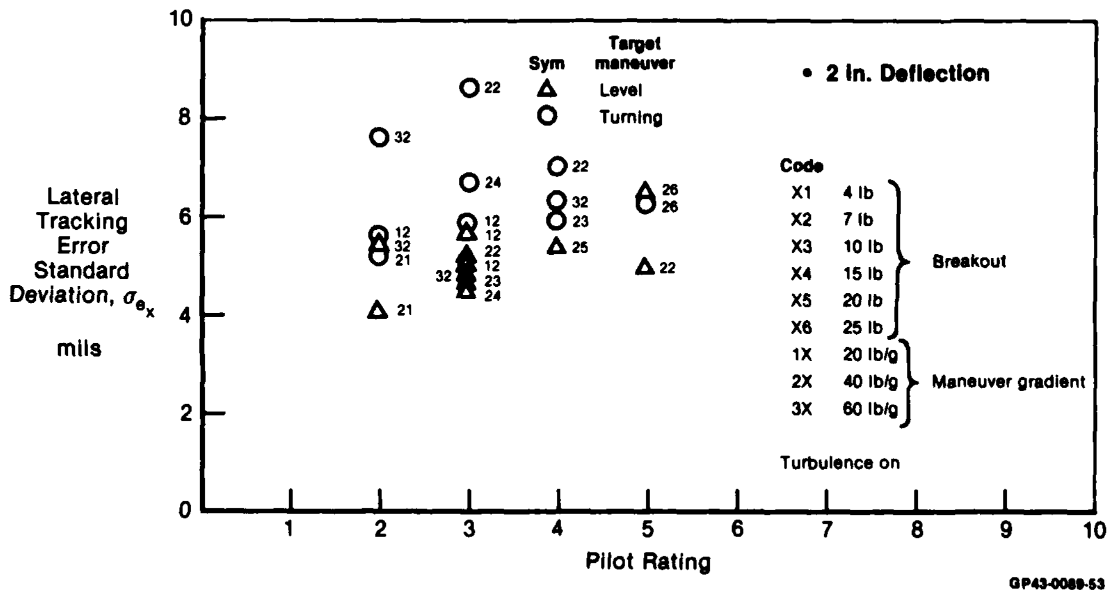

Figure 147. Lateral Tracking Error vs Pilot Rating
Rudder Pedals Wings Level Turn Pilot 21

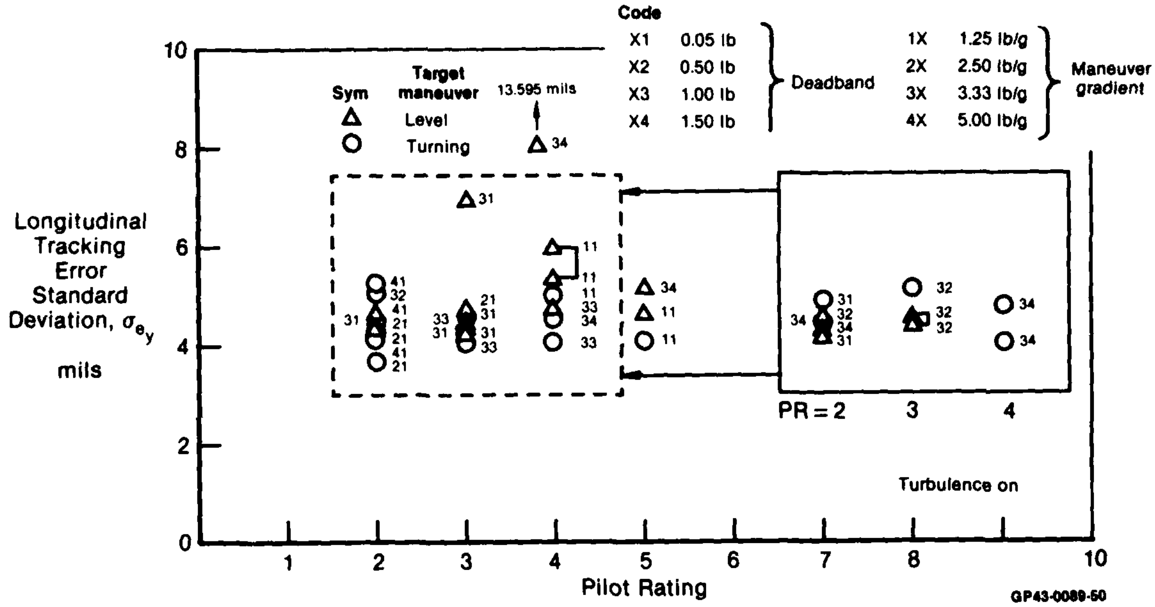

Figure 148. Longitudinal Tracking Error vs Pilot Rating
Thumb Button Controller Wings Level Turn Pilot 21

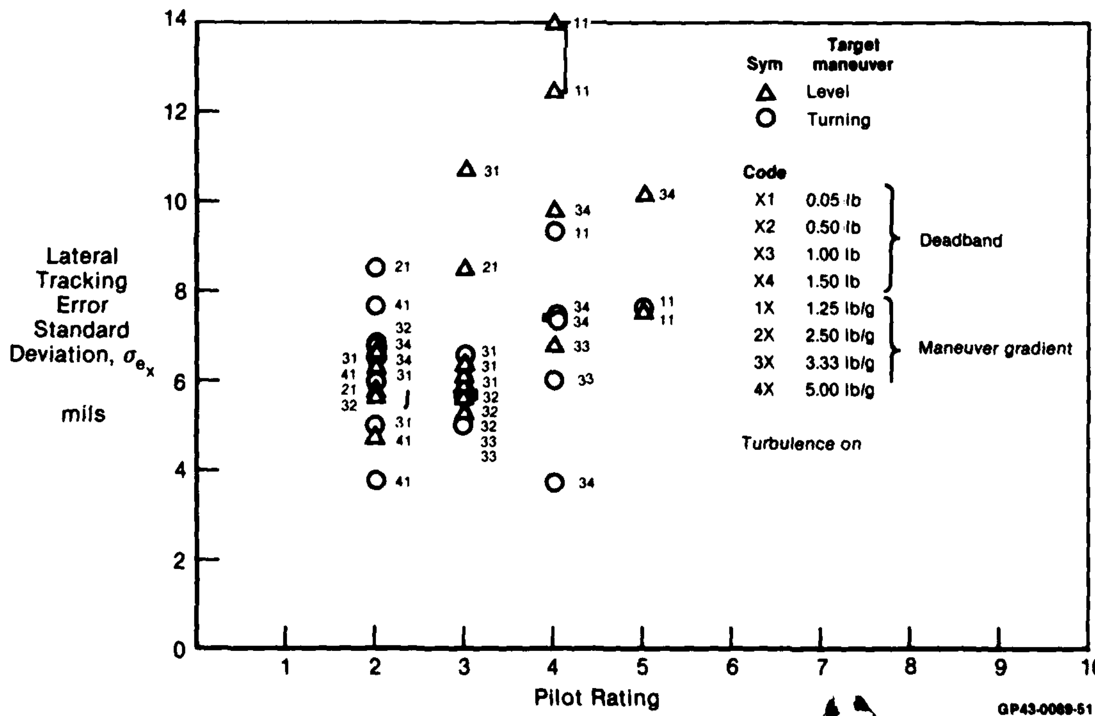

Figure 149. Lateral Tracking Error vs Pilot Rating
Thumb Button Controller Wings Level Turn Pilot 21

It is felt that this method worked well in minimizing differences in pilot ability. The better pilots could not relax because of "too loose" definitions of adequate and acceptable performance. Those pilots who had more trouble with the tasks were not forced to degrade their ratings due to "too tight" a specification of performance goals. Future efforts should consider this technique as a way of "accounting" for pilot abilities and as a means of stimulating pilot performance.

13. SPECTRAL ANALYSIS OF PILOTED SIMULATION - To further quantify the effect of controller variations on pilot control inputs and pilot opinion, a spectral analysis of the real time piloted simulation data was conducted. During the approach and landing evaluations, several runs were used to establish types of disturbances and analysis techniques to use in spectral analysis of the time history data. These techniques were then applied to a large portion of air-to-air tracking evaluations conducted by Pilot 21. Following his initial evaluation of the air-to-air test matrix, Pilot 21 duplicated much of this matrix with the addition of atmospheric turbulence and motion system disturbances. The wing level turn dynamics, tasks and controller configuration were the same as those used in the earlier evaluations.

a. Description of the Control Task, Objectives, and Analytical Techniques - The control task is depicted in the block diagram of Figure 150. For the experiments analyzed herein, the pilot was instructed to track the target motions (i.e., keep the target in the pipper) using the wings-level-turn controller (δ_{WLT}) and to keep the wings level using the roll controller (δ_p). This has been previously identified as the level target task.

Using the wings level turn (WLT) mode (also referred to as a flat turn mode), the pilot can turn the aircraft without any sideslip and without changing the roll attitude. The appropriate transfer functions for the WLT mode are shown below.

$$\frac{r}{\delta_{WLT}} = \frac{1.0}{0.5s + 1.0} N_{\delta_{WLT}} \quad Y_{C_{WLT}} \tag{1}$$

$$\frac{\beta}{\delta_{WLT}} = 0 \tag{2}$$

$$\frac{\phi}{\delta_{WLT}} = 0 \tag{3}$$

$$n_y = \frac{U}{g} r \tag{4}$$

Where $N_{\delta_{WLT}}$ was used to set the maximum control power. For the experiments described herein, the control power was $n_{y_{max}} = 1.0$ g at the specified maximum force.

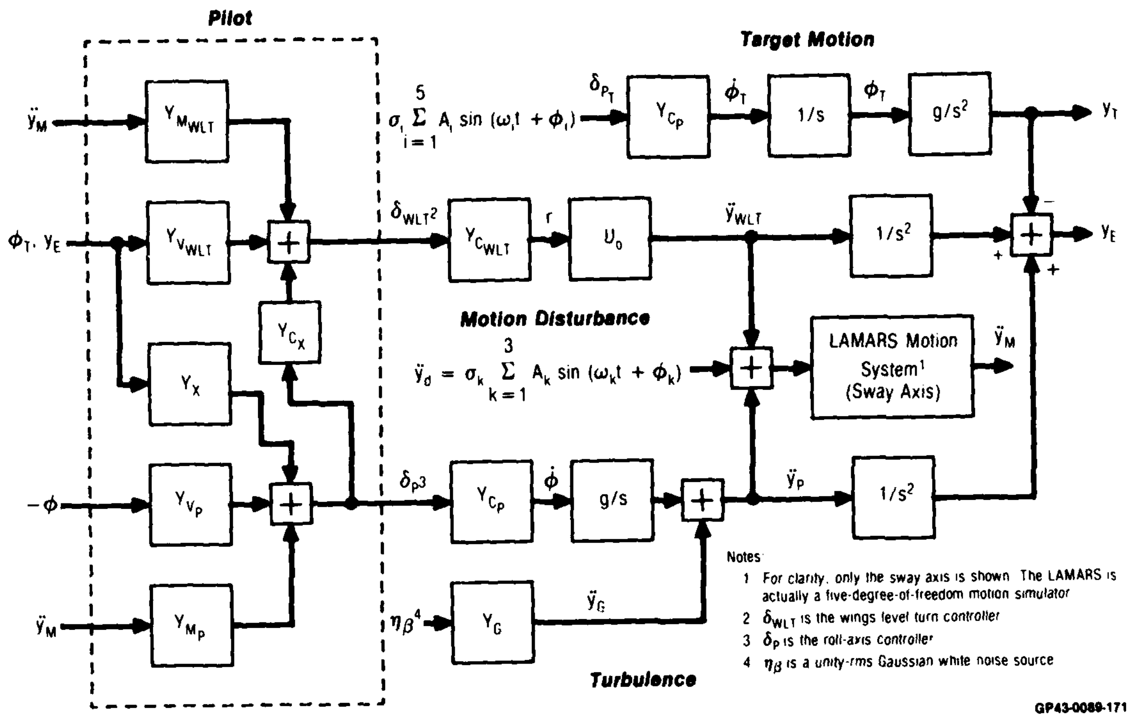

Figure 150. Functional Block Diagram of Pilot Control Task, Target Motion, and Motion Disturbance for Air-to-Air Tracking Task

The appropriate transfer functions for the roll mode are shown below:

$$\frac{p}{\delta_p} = \frac{L_{\delta_p}}{0.35s + 1} \quad Y_{C_p} \tag{5}$$

$$\frac{\beta}{\delta_p} = 0 \tag{6}$$

Where L_{δ_p} was used to set the maximum control power. For the experiments described herein, the control power was p_{max} = 150 deg/sec at maximum side stick deflection. The roll side stick sensitivity was 12.5 deg/sec per pound of δ_p.

The pilot's control actions shown in Figure 150 are represented by a sum of linear feedbacks proportional to the aircraft's bank angle (ϕ), the target's bank angle (ϕ_T), the difference between the tracker and the target aircraft lateral position, represented by the pipper error (y_E), and the lateral acceleration ($\ddot{y}_M$). The y_E and ϕ feedbacks are represented by $Y_{V_{WLT}}$ and Y_{V_p}, respectively. The crossfeed term, Y_X, is in Figure 150, because some pilots may "cheat" by using the roll controller, δ_p, to chase the target. The target bank angle is

fed back through $Y_{V_{WLT}}$, because it is possible to use ϕ_T to anticipate the target motion and thus generate lead. Controller cross-coupling is represented by the term Y_{C_X}. The coupling is shown with the roll controller summing with the WLT controllers, but the opposite direction is also possible. "Biodynamic" feed-through is represented by the terms $Y_{M_{WLT}}$ and Y_{M_P}, which represent how the aircraft's lateral acceleration, $\ddot{y}$, affect the pilot's controls, δ_{WLT} and δ_p, respectively.

The aircraft is being disturbed by two noise sources, as shown in Figure 150. Dryden style turbulence is injected into the equations of motion, while the motion disturbance is injected directly into the LAMARS motion system; thus, it is uncorrelated with the aircraft motion. The purpose of the turbulence is to add realism to the simulation. The transfer function for the turbulence is:

$$Y_G \quad \frac{\ddot{y}_G}{\eta_\beta} = \frac{n_y}{\beta}\,\frac{g}{U}\,\frac{\omega_{dr}^2 \quad \sigma_{v_g} \quad (3R_\beta)^{1/2}}{[\zeta_{dr};\omega_{dr}]\ (s + 1.5\ R_\beta)} \tag{7}$$

where R_β = U/1750 rad/sec, σ_{v_g} = 3.0 fps, ω_{dr} = 4.47 rad/sec, ζ_{dr} = 0.68, and η_β is a unity amplitude Gaussian noise source.

The purpose of the motion disturbance is to quantify how aircraft accelerations will affect the use of the various controllers. Since the motion disturbance, $\ddot{y}_d$, is formed by a sum of three discrete sine waves, it is possible to "trace" the signals through to the controllers, δ_{WLT} and δ_p. Thus the terms $Y_{M_{WLT}}$ and Y_{M_p} could theoretically be identified. The amplitudes, A_k, and frequencies, ω_k, used to form $\ddot{y}_d$ are listed in Table 2. The phase angles, ϕ_k, were randomly chosen from run to run. The magnitude of the motion disturbance was subjectively set such that the motion could be felt but was not a dominant effect. The subject test pilots were not informed of the motion disturbance.

The target aircraft motions, ϕ_T and Y_T shown in Figure 168, were formed by using a sum of five sine waves as the input to the roll controller. The target motions were recorded on magnetic media and then played back during realtime simulation. The phasing between the sine waves, ϕ_i, was set such that a zero-mean process for ϕ_p was obtained, and the target aircraft was constrained to remain in the same horizontal plane. The magnitude of the input, ϕ_i, was set such that the root-mean-square (rms) bank angle of the target aircraft was approximately 15 deg. The amplitudes, A_i, and frequencies, ω_i, used to form δ_{p_T}, previously shown in Table 1, are reprinted in Table 3. Because the power in the target motion exists at discrete frequencies, it is theoretically possible to identify the terms $Y_{V_{WLT}}$, Y_X, Y_{C_X}, and Y_{V_p}.

TABLE 2. MOTION SYSTEM DISTURBANCES

Heave Axis:

$$\Delta\ddot{h} = \sigma_{\Delta\ddot{h}} \sum_{i=1}^{3} A_i \sin(\omega_i t + \phi_i)$$

i	A_i	ω_i (rad/sec)	Harmonic Number (5 sec Period)
1	0.9422	13.82	11
2	0.8134	20.11	16
3	0.6713	28.90	23

$\sigma_{\Delta\ddot{h}} = 5$

Side Force Axis:

$$\Delta\ddot{y} = \sigma_{\Delta\ddot{y}} \sum_{k=1}^{3} B_k \sin(\omega_k t + \phi_k)$$

K	A_K	ω_k (rad/sec)	Harmonic Number (5 sec Period)
1	0.9698	11.31	9
2	0.7886	16.34	13
3	0.6616	23.88	19

$\sigma_{\Delta\ddot{y}} = 5$

Note: All ϕ are random numbers computed at beginning of run. They are held constant throughout a run.

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TABLE 3. SUMS OF SINES TARGET DRIVE SIGNALS

From: $\Delta p = \sigma_{\Delta p} \sum_{i=1}^{5} A_i \sin(W_i t + \phi_i)$

i	A_i	ω_i (rad/sec)	Harmonic Number (Cycles/Run Length)
1	0.9328	0.25	2
2	0.7838	0.63	5
3	0.5825	1.88	15
4	0.3519	4.40	35
5	0.2290	9.42	75

$\sigma_{\Delta 1p} = 0.145$ for Turning Target
$= 0.290$ for Level Target

Note: ϕ_i all set to $+\pi/2$ for one target record and $-\pi/2$ for other

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The overall objective of the analysis contained herein is to quantify how the pilot interacts with the various novel controllers and control modes described herein, including:

1. Controller versus aircraft response behavior (e.g., pilot control strategy and describing functions). This can be quantified by the terms $Y_{V_{WLT}}$, Y_X, and Y_{V_p} in Figure 150.

2. Controller-to-controller cross-coupling (e.g., roll commands due to twist grip deflections). This can be quantified by the term Y_{C_X} in Figure 150.

3. Aircraft motion-to-controller coupling ("biodynamic cross-coupling"). This can be quantified by identifying the terms $Y_{M_{WLT}}$ and Y_{M_p} in Figure 150.

As mentioned above, it is theoretically possible to identify the terms in Figure 150 by using describing function and/or time domain analysis techniques. Due to time and resource constraints and the intensive level of computations required we were unable to complete the analysis. Instead, the next section presents the power spectra and power fractions of the roll and WLT controllers for a selected group of runs. By examining the power spectra, we can tell if the disturbances are present in the controllers; that is, if the pilot can be modeled as a linear system as shown in Figure 150, then all the power in δ_{WLT} would be at the target frequencies, ω_i. Furthermore, if the pilot did not use the roll controller to track the target, then the power in δ_p would be "white" (i.e., because the Dryden turbulence is shaped white noise). If biodynamic coupling exists, then there will also be power in δ_p and/or δ_{WLT} at the motion disturbance frequencies, ω_k.

b. <u>Analysis of Air-to-Air Tracking Data</u> - The analysis contained below compares the data from three different types of controllers used to perform an air-to-air tracking task using a wings-level-turn (WLT) mode. The three controllers were:

1. Conventional rudder pedals, δ_{RP}.

2. The twist grip controller, δ_{TG}. This was the twist axis of the sidestick controller.

3. The thumb button controller, δ_{TBC}, mounted on the sidestick controller.

Table 4 is a summary of the runs analyzed. Note that the maneuver gradient was held constant for each of the WLT controllers while either the deadband (DB) for the twist grip or thumb button or breakout force (BO) for the rudder pedals was varied. As shown in Table 4, the pilot rating (CH) varied from 2 to 5 as a function of either deadband or breakout force.

TABLE 4. RUN ANALYSIS SUMMARY

Figure Number	Run Number	WLT Controller	Controller Characteristics	CHR	Pilot Comments	Analysis Comments
151	3,145	Rudder Pedals*	4.0 lb BO**	2	"Feels Better Easier to Do."	Very Little Motion Feedthrough to δ_{RP}. Lots to δ_P. Some Possible Crosscoupling
152	3,137		7.0 lb BO	3	"Not Bad, But Not Great"	No Motion Feedthrough to δ_{RP}. Still Lots to δ_P. Some Possible Crosscoupling
153	3,141		15.0 lb BO	3	"Feet Got Tired"	Same as Above
154	3,143		25.0 lb BO	5	"Too Much Pedal to Start and Stop"	Strange Looking Spectra for δ_{RP}. Note Jump in CH from 3 to 5
155	3,081	Twist Grip#	0.48 in.-lb DB**	2	"No Problem"	Lots of Motion Feedthrough. Definite Crosscoupling at ω = 1.8 rad/sec
156	3,084		2.7 in.-lb DB	3	"Has a Little Lag"	Same as Above
157	3,092		4.8 in.-lb DB	4	"Didn't Respond Quickly"	Motion Feedthrough and Crosscoupling Reduced
158	3,086		9.6 in.-lb DB	5	"Too Much Delay"	Definite Crosscoupling. No Motion Feedthrough
159	3,188	Isometric Button##	0.05 lb DB	3	"Little Loose"	Lots of Crosscoupling and Motion Feedthrough
160	3,190		0.50 lb DB	3	"Not a Bad One"	Reduced Coupling and Motion Feedthrough
161	3,194		1.0 lb DB	3	"Too Much Force to Get It Going"	Further Reduction in Coupling and Motion Feedthrough. Note That CH Remains 3
162	3,192		1.5 lb DB	5	"Bad"	Increased Use of δ_P. Note That CH Jumped to 5

Notes

* Rudder pedals had 2 in. of travel and a maneuver gradient of 40 lb/g

** DB = deadband BO = breakout

\# Twist grip had a maneuver gradient of 24 in.-lb/g and was the rotational axis on the two-axis right handed sidestick

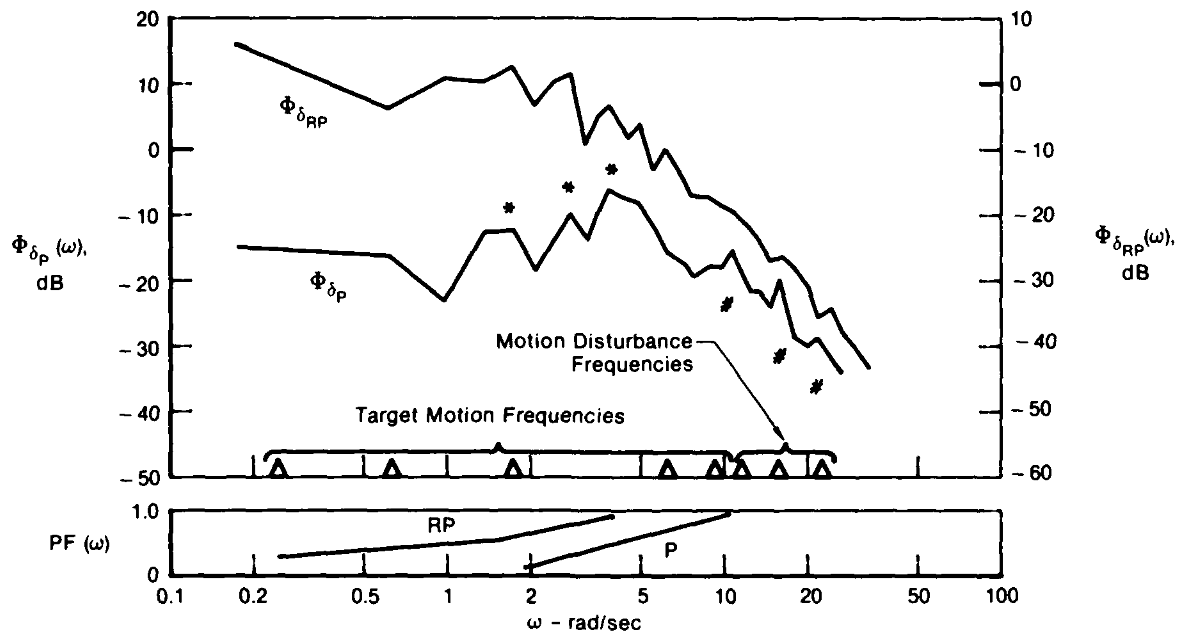
\#\# Isometric button has a maneuver gradient of 3.3 lb/g and was mounted on the two axis right handed sidestick

GP43-0089-170

Figures 151 through 162 contain power spectra and power fraction plots of the roll controller and the appropriate WLT controller. The power fraction is a unique way to visualize the spectral distribution in a signal. It is defined as follows:

$$PF(\omega) = \frac{1}{\sigma_x^2} \int_0^{\omega} \phi_{xx}(\omega)dx$$

Note that $\sigma_x^2 \equiv PF(\omega = \infty)$, thus $PF(\omega)$ is a fraction from 0.0 to 1.0. The unique feature of the power fraction is that it defines the bandwidth of a signal in terms of a percentage (e.g., 90 percent of the power is below 5.2 rad/sec).



Notes:

* Crosscoupling between controllers suggested by line spectra in Φ_{δ_P} and $\Phi_{\delta_{RP}}$ at the same frequency. However, at the target disturbance frequency, this could also be due to the pilot using δ_P to "chase" the target (even though he was instructed not to do so).

Motion feedthrough evidenced by line spectra at motion disturbance frequencies.

GP43-0089-103

Figure 151. Power Spectra [$\Phi(\omega)$] and Power Fraction [$PF(\omega)$] for Wings Level Turn and Roll Control Input

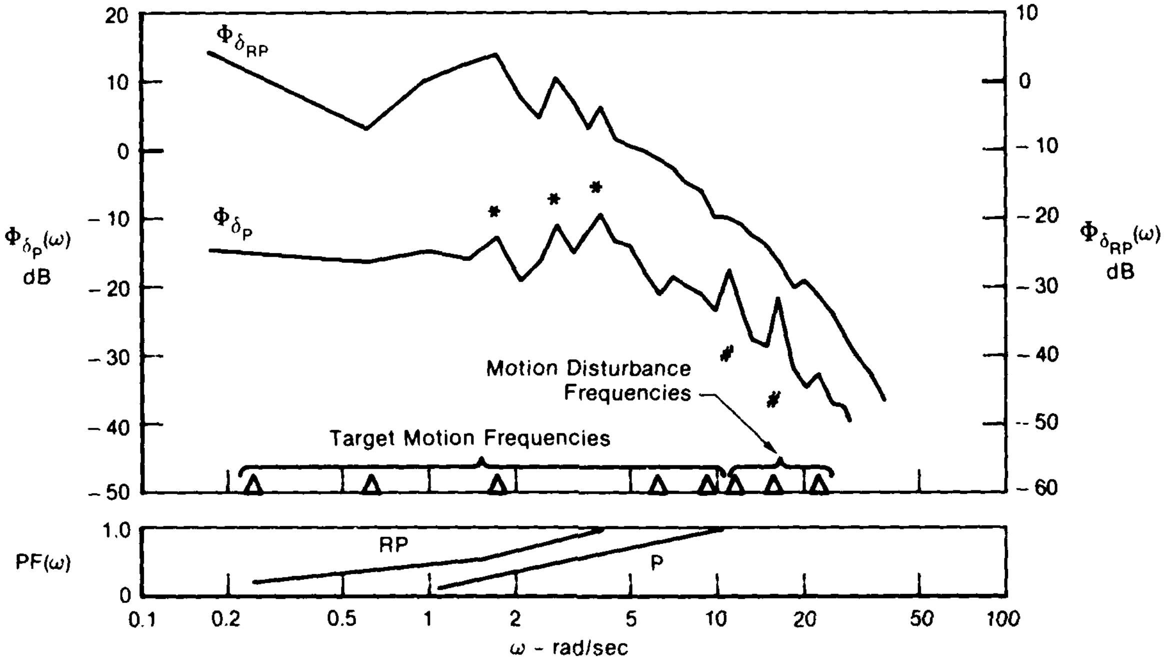
Rudder Pedal, 2 In. Deflection   4 Lb Breakout, 40 Lb/g Maneuver Gradient

Cooper-Harper 2

The following observations were made after carefully examining these plots in Figures 151 through 162:

1. There are large amounts of motion feedthrough ("biodynamic coupling") to the roll controller (i.e., lateral side stick) for all runs. This is evidenced by the "line spectra" (i.e., the spikes or apparent discontinuities noted in the power spectra plots) at the motion disturbance frequencies. It is interesting to note that none of the pilots complained of motion-to-controller coupling. This is probably because the accelerations were small in amplitude and were masked by the Dryden turbulence. However, motion-to-controller coupling can have extremely detrimental effects in actual flight where the accelerations are much larger.

2. There is evidence of motion feedthrough on all of the WLT controllers, with the most on the twist grip and the least on the rudder pedals. As the deadband is increased, the evidence of motion feedthrough is decreased.



Notes:

* Crosscoupling between controllers suggested by the line spectra in Φ_{δ_P} and $\Phi_{\delta_{RP}}$ at the same frequency. However, at the target disturbance frequency, this could also be due to the pilot using δ_P to "chase" the target (even though he was instructed not to do so).

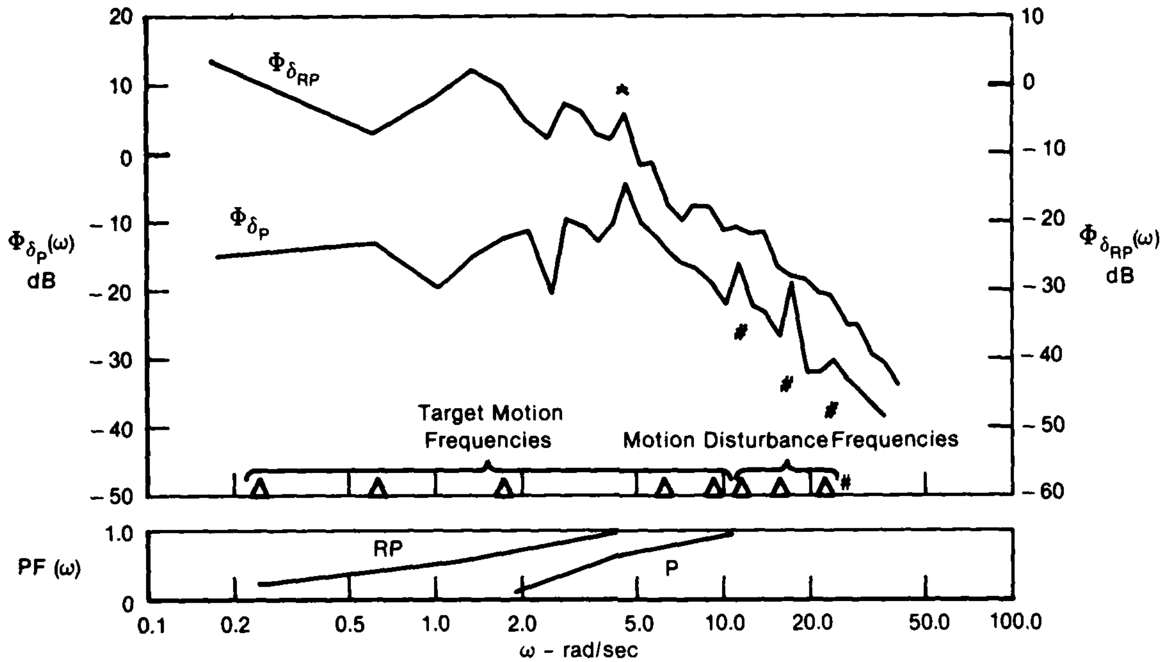
\# Motion feedthrough evidenced by line spectra at motion disturbance frequencies.

GP43-0089-104

Figure 152. Power Spectra [$\Phi(\omega)$] and Power Fraction [PF(ω)] for Wings Level Turn and Roll Control Inputs

Rudder Pedal, 2 In. Deflection 7 Lb Breakout, 40 Lb/g Maneuver Gradient
Cooper-Harper 3

3. There appears to be controller cross-coupling between the roll and WLT controllers for the twist grip and thumb button but very little for the rudder pedals. This is evidenced by the line spectra in δ_P and δ_{WLT} at the same frequencies. This is especially true (and consistent) at the motion disturbance frequencies and makes sense, because the pilot must grab the sidestick in order to use the twist grip or the thumb button but not to use the rudder pedals.



Notes:

* Crosscoupling between controllers suggested by the line spectra in Φ_{δ_P} and $\Phi_{\delta_{RP}}$ at the same frequency. However, at the target disturbance frequency, this could also be due to the pilot using δ_P to "chase" the target (even though he was instructed not to do so).

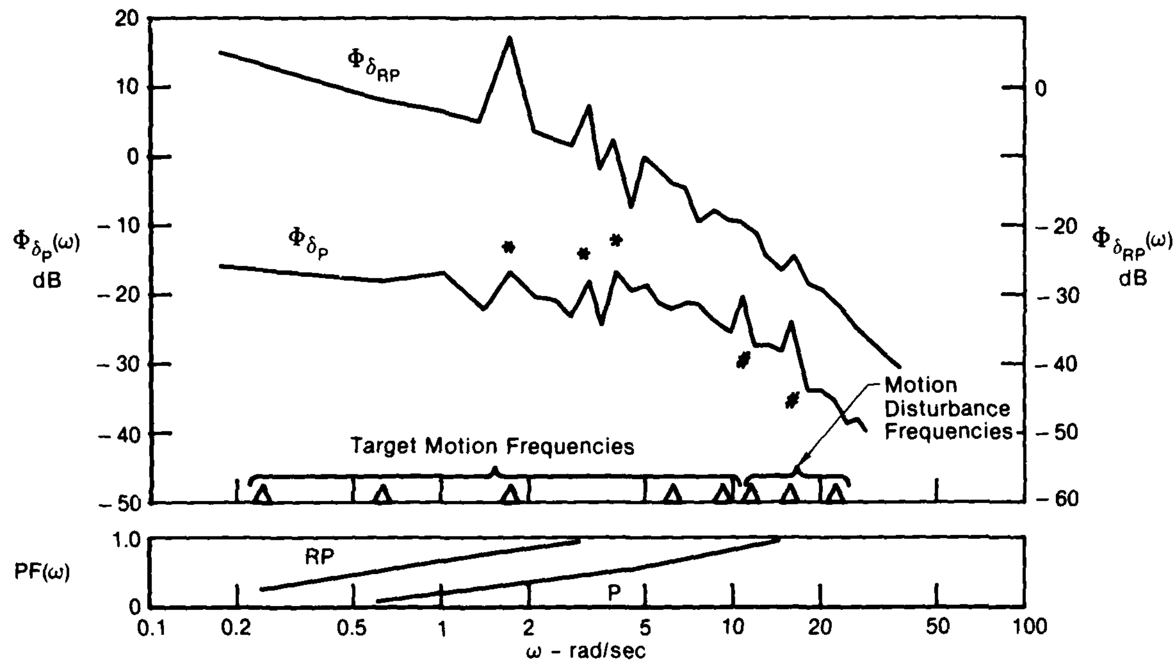
Motion feedthrough evidenced by line spectra at motion disturbance frequencies.

GP43-0089-105

Figure 153. Power Spectra [Φ(ω)] and Power Fraction [PF(ω)] for Wings Level Turn and Roll Control Inputs

Rudder Pedal, 2 In. Deflection 15 Lb Breakout, 40 Lb/g Maneuver Gradient
Cooper-Harper 3

4. Note that the rudder pedals are the only controller for which clear line spectra do appear at the target disturbance frequencies and do not appear at the motion disturbance frequencies. All the other controllers (roll sidestick, twist grip and thumb button) exhibit line spectra at both disturbance frequency levels. Note also that for the rudder pedal plots, line spectra do appear for the roll controller at the target disturbance frequencies. Since physical coupling is not possible between these controllers, the plots suggest the pilot is consciously or unconsciously using the roll controller to assist in chasing the target. It is probably a combination of both mental coupling and chasing, as the coupling seems stronger in the twist grip and thumb button plots (i.e. the magnitudes of the spikes in the roll controller are larger) where anthropomorphic coupling is possible.



Notes:

* Crosscoupling between controllers suggested by the line spectra in Φ_{δ_P} and $\Phi_{\delta_{RP}}$ at the same frequency. However, at the target disturbance frequency, this could also be due to the pilot using δ_P to "chase" the target (even though he was instructed not to do so).

\# Motion feedthrough evidenced by line spectra at motion disturbance frequencies.

GP43-0089-106

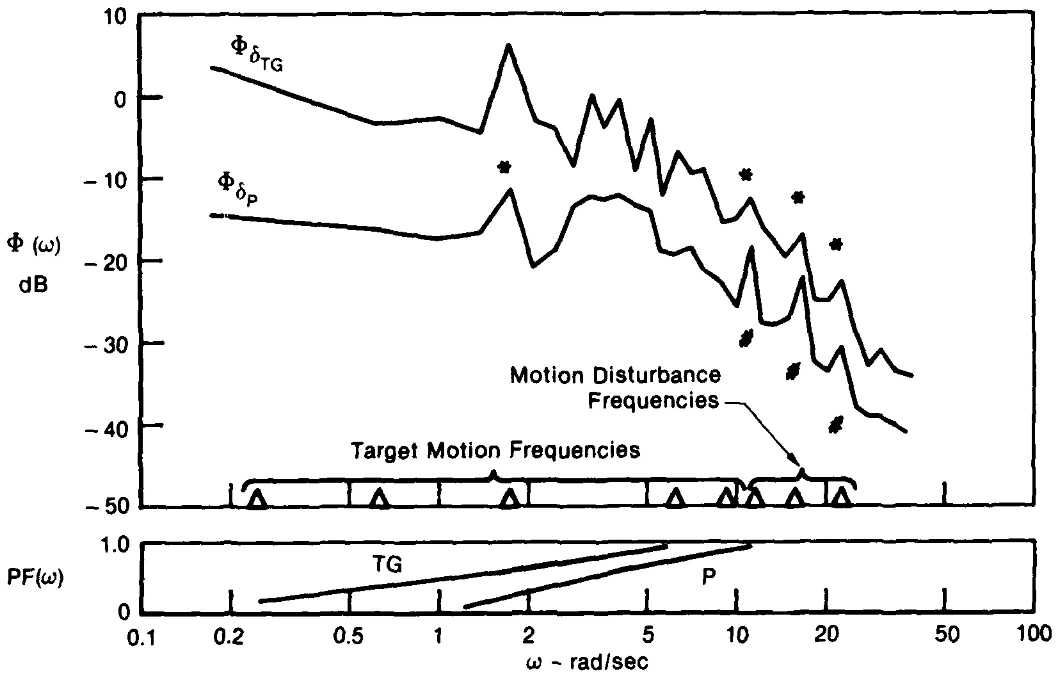
Figure 154. Power Spectra [Φ(ω)] and Power Fraction [PF(ω)] for Wings Level Turn and Roll Control Inputs

Rudder Pedal, 2 In. Deflection 25 Lb Breakout, 40 Lb/g Maneuver Gradient
Cooper-Harper 5

5. Line spectra at all of the disturbance frequencies were not clearly or consistently observed (ω = 1.8 rad/sec is the only possible exception to this observation). This is probably due to nonlinearities in the pilot's control technique such as saturation (e.g., bang-bang control) or aperiodic sampling.

c. <u>Conclusions and Recommendations</u> - Using spectral analysis techniques, it was possible to identify controller cross coupling for the air-to-air combat task described herein. However, because of the nature of the task, it was not possible to discern whether the coupling was proprioceptive (e.g., twisting the sidestick to effect the wings level turn mode without affecting the roll controller) or whether the pilot was intentionally using both controllers to improve tracking performance. We recommend performing two additional tasks which will help to isolate the coupling effects:

- o Track the target without the WLT controller. This will reveal how much roll control is being used when the pilot is not using the WLT controller.



Notes:

* Crosscoupling between controllers suggested by the line spectra in Φ_{δ_P} and $\Phi_{\delta_{TG}}$ at the same frequency. However, at the target disturbance frequency, this could also be due to the pilot using δ_P to "chase" the target (even though he was instructed not to do so).

\# Motion feedthrough evidenced by line spectra at motion disturbance frequencies.

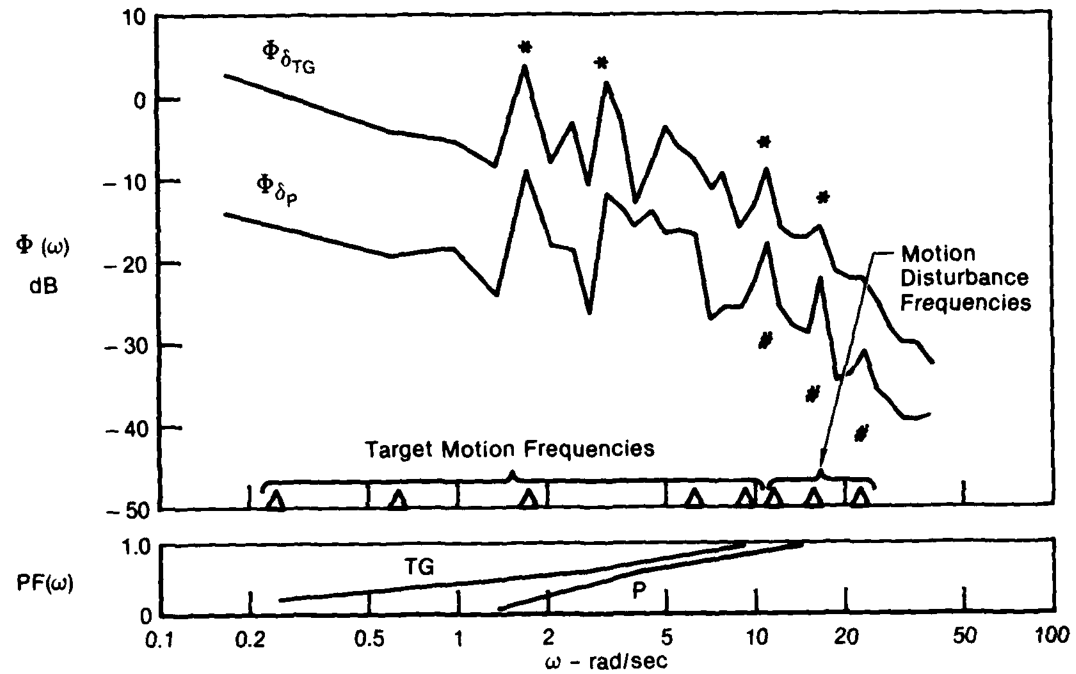
GP43-0089-107

Figure 155. Power Spectra [Φ(ω)] and Power Fraction [PF(ω)] for Wings Level Turn and Roll Control Inputs

Twist Grip Sidestick 0.48 In.-Lb Deadband, 24 In-Lb/g Maneuver Gradient
Cooper-Harper 2

o Track the target with the roll axis of the aircraft fixed (i.e., short the connection between δ_p and the roll axis equations of motion). Reduce the deadband on δ_p to zero, and measure the spectra of δ_p.

The first task would assist in giving the observer a feel for what spectra would be expected for a pilot actively chasing the target with the roll controller. The second task would yield spectra for the use of the WLT controller without roll axis chasing contamination. Some caution must be applied when using this task, however. Since there would be no penalty (i.e. roll response) for making roll inputs, the pilot might modify his technique to such an extent as to invalidate the spectra of δ_p. This effect could be minimized by providing the pilot some form of feedback, other than roll response, to indicate when roll inputs are being made.



Notes:

* Crosscoupling between controllers suggested by the line spectra in Φ_{δ_P} and $\Phi_{\delta_{TG}}$ at the same frequency. However, at the target disturbance frequency, this could also be due to the pilot using δ_P to "chase" the target (even though he was instructed not to do so).

Motion feedthrough evidenced by line spectra at motion disturbance frequencies.

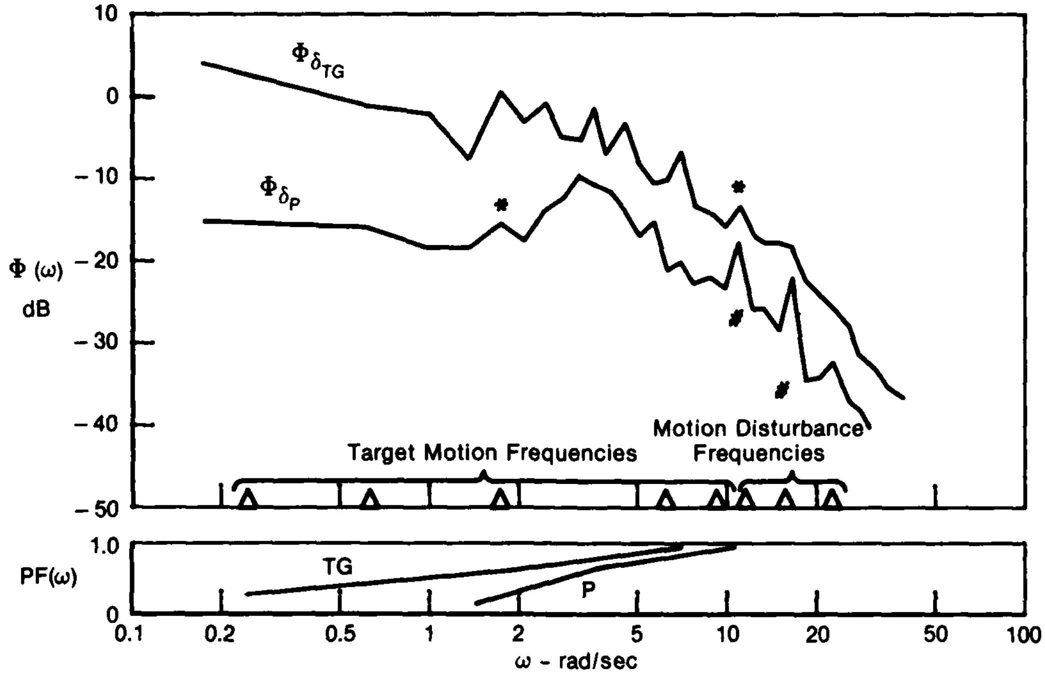
GP43-0089-108

Figure 156. Power Spectra [Φ(ω)] and Power Fraction [PF(ω)] for Wings Level Turn and Roll Control Inputs

Twist Grip Sidestick 2.7 In.-Lb Deadband, 24 In.-Lb/g Maneuver Gradient
Cooper-Harper 3

Spectral analysis of the controller signals also revealed large amounts of biodynamic coupling; that is, the aircraft accelerations were feeding through to the controllers by way of the pilot's limbs. Because the simulated accelerations are quite small relative to the real world, none of the subject pilots complained of motion feedthrough problems. We recommend that analytic techniques be used to predict the amount of acceleration to expect in real flight and how the accelerations will affect overall performance of the pilot-aircraft system. Existing tools such as Biodyn (Ref. 72) and USAM (Ref. 73) could be used to perform this task.

We also recommend a complete pilot-vehicle analysis. Using a loop structure like the one shown in Figure 150, the closed-loop characteristics of the pilot-vehicle system could be predicted. The effects of cross-axis coupling and motion feedthrough could be quantified.



Notes:

* Crosscoupling between controllers suggested by the line spectra in Φ_{δ_P} and $\Phi_{\delta_{TG}}$ at the same frequency. However, at the target disturbance frequency, this could also be due to the pilot using δ_P to "chase" the target (even though he was instructed not to do so).

\# Motion feedthrough evidenced by line spectra at motion disturbance frequencies.

GP43-0069-109

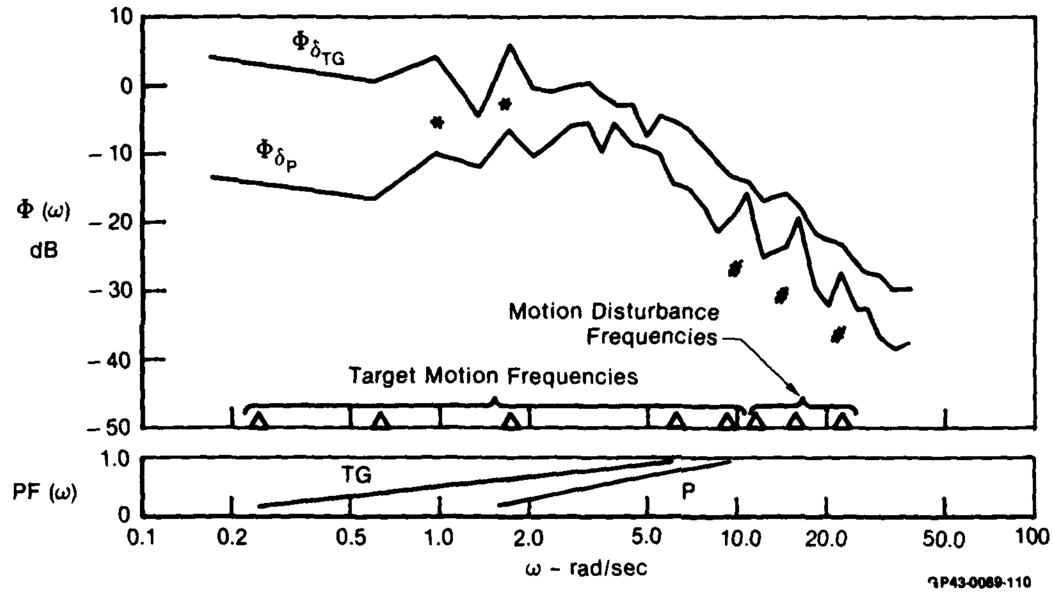
Figure 157. Power Spectra [$\Phi(\omega)$] and Power Fraction [PF(ω)] for Wings Level Turn and Roll Control Inputs

Twist Grip Sidestick 4.8 In.-Lb Deadband, 24 In.-Lb/g Maneuver Gradient

Cooper-Harper 4

14. <u>CONCLUSIONS AND RECOMMENDATIONS</u> - During the course of the simulation and analysis of the resulting data, many "lessons" were identified. These take two forms, those dealing with controller characteristics and those lessons dealing with simulation in general. In this section we will examine some of these lessons.

a. <u>Lessons on Simulation</u> - In this simulation we were examining new and unfamiliar aircraft response characteristics. There are no "pools" of pilots familiar with uncoupled motion responses and tactics. Due to schedule conflicts and the prolonged duration of this simulation, fourteen pilots participated in the evaluations. Each pilot was given as much practice time as possible in the tasks he was to perform. It is felt that this was too large a group of pilots to ensure uniform capabilities with uncoupled mode usage. Also, because each pilot's availability was limited, the desired number of reevaluations was often not achieved. Boredom was another drawback associated with a large number of pilots and limited time with each pilot. Since



Notes:

* Crosscoupling between controllers suggested by the line spectra in Φ_{δ_P} and $\Phi_{\delta_{TG}}$ at the same frequency. However, at the target disturbance frequency, this could also be due to the pilot using δ_P to "chase" the target (even though he was instructed not to do so).

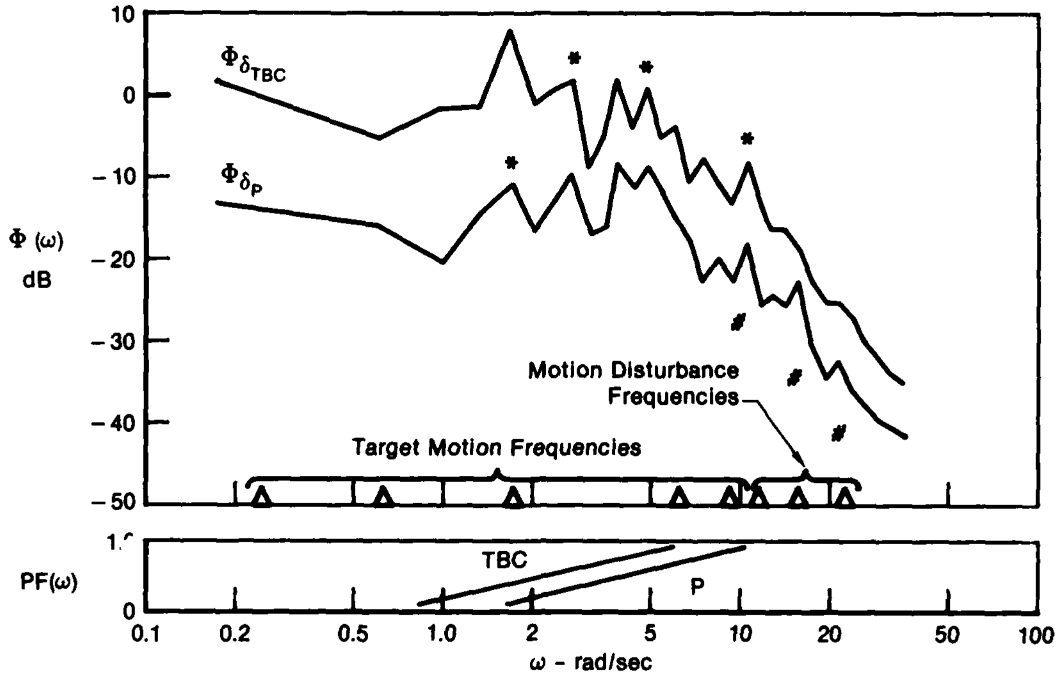
\# Motion feedthrough evidenced by line spectra at motion disturbance frequencies.

Figure 158. Power Spectra [$\Phi(\omega)$] and Power Fraction [PF(ω)] for Wings Level Turn and Roll Control Inputs

Twist Grip Sidestick 9.6 In.-Lb Deadband, 24 In.-Lb/g Maneuver Gradient
Cooper-Harper 5

each pilot was available for approximately one week, controller variations were concentrated on one mode and one task. Some of the pilots commented in the post simulation questionnaires that they would have preferred to look at additional modes and/or tasks. Unfortunately, due to the limited duration of pilot availability, this would have destroyed any continuity in the areas to be covered. In conclusion, it is recommended that future efforts limit the number of participants to three or four and concentrate on giving the pilots as much familiarity with each mode and task as possible.

Another area in which the pilots expressed a definite opinion was in the length of the simulation sessions. This was a motion based simulation and as such the pilots had to deal with an environment that was applying forces to them. In addition, the display was a mono-chromatic projection in tones of green. The result was a certain amount of eye strain when attempting to determine the exact location of the "target". This was particularly true when using the terrain board projections. The combined mental and physical workload associated with the simulation produced a definite feeling of fatigue in sessions lasting more than one hour. As a result the quality and repeatability of the



Notes:

* Crosscoupling between controllers suggested by the line spectra in Φ_{δ_P} and $\Phi_{\delta_{TBC}}$ at the same frequency. However, at the target disturbance frequency, this could also be due to the pilot using δ_P to "chase" the target (even though he was instructed not to do so).

\# Motion feedthrough evidenced by line spectra at motion disturbance frequencies.

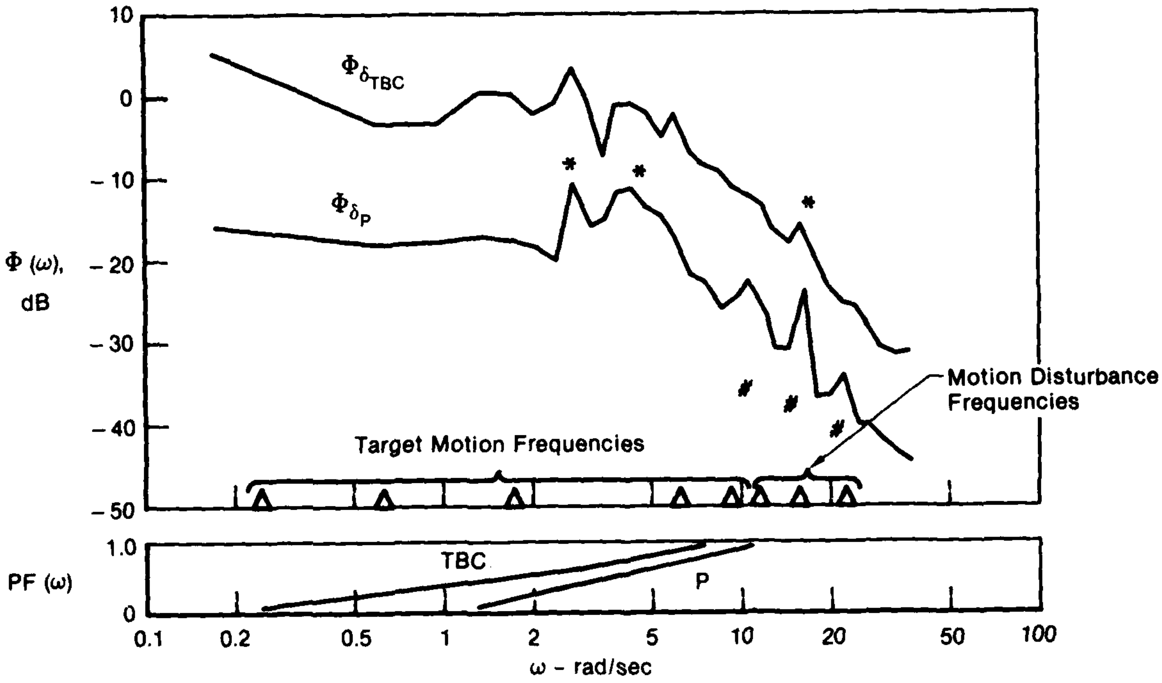
GP43-0089-111

Figure 159. Power Spectra [Φ(ω)] and Power Fraction [PF(ω)] for Wings Level Turn and Roll Control Inputs

Thumb Button Controller   0.05 Lb Deadband, 3.3 Lb/g Maneuver Gradient
Cooper-Harper 3

pilot ratings declined. It is recommended that future efforts consider limiting motion-based evaluations to one hour and fixed base sessions to approximately 1-1/2 hours. Additionally, if multiple sessions are to be accomplished by a pilot in a given day, succeeding sessions should be shortened accordingly.

Pilots vary significantly in the manner in which they arrive at a pilot rating. All pilots involved in this simulation had some familiarity with the Cooper-Harper rating scale. However, none of the pilots were current in its application. The pre-simulation briefing included a detailed discussion of proper use of the scale. During each run we accepted free-form pilot comments. When the pilot was ready to assign a rating, the best technique was to have the pilot orally 'read' his way through the decision logic. Two benefits were gained from this. The technique ensured that the pilots were using the decision tree logic structure of the scale and not just picking the rating from the adjective description next to each rating. Additionally, the



Notes:
* Crosscoupling between controllers suggested by line spectra in Φ_{δ_p} and $\Phi_{\delta_{TBC}}$ at the same frequency. However, at the target disturbance frequency, this could also be due to the pilot using δ_p to "chase" the target (even though he was instructed not to do so).

Motion feedthrough evidenced by line spectra at motion disturbance frequencies.

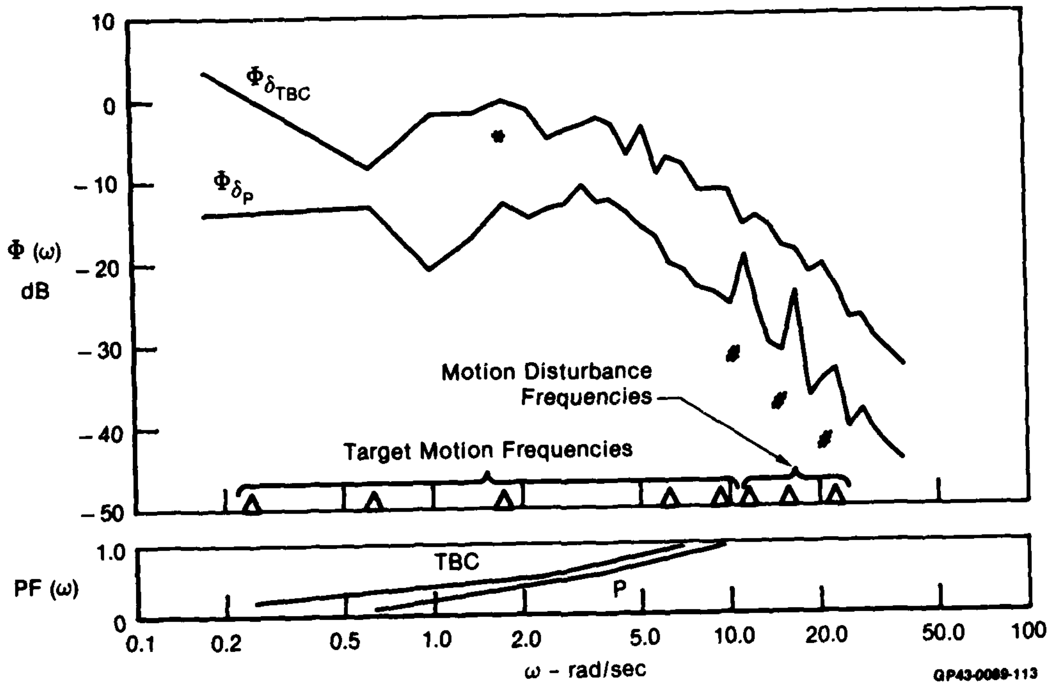
GP43-0089-112

Figure 160. Power Spectra [$\Phi(\omega)$] and Power Fraction [PF(ω)] for Wings Level Turn and Roll Control Input

Thumb Button Controller 0.5 Lb Deadband, 3.3 Lb/g Maneuver Gradient
Cooper-Harper 3

method often prompted additional comments which occurred to the pilots as they read through the scale. As mentioned in a previous section, a copy of the Cooper-Harper rating scale and a suggested pilot comment card were available in the cockpit. This method of orally 'reading' the scale developed during the simulation and was not part of the original pilot procedures. Therefore, not all pilots followed this method. It is felt the uniform application of this technique would go a long way in minimizing the scatter and increasing the predictability of pilot opinion ratings.

During the air-to-ground evaluations, it was noted that the pilots varied significantly in the number of runs for each pilot rating. The pilots had been instructed to request additional runs for each configuration until they were confident of the rating. Three or four runs were typically used to determine the pilot rating. On some occasions, however, a pilot would decide to assign a rating after only one run. A review of the pilot



Notes:

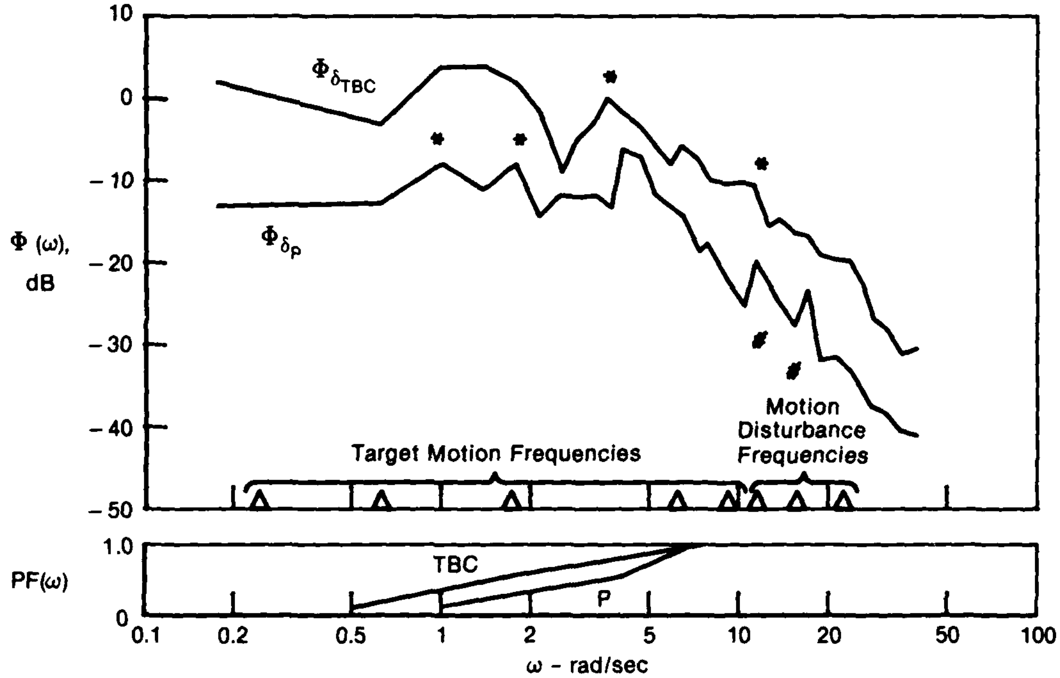
* Crosscoupling between controllers suggested by the line spectra in Φ_{δ_P} and $\Phi_{\delta_{TBC}}$ at the same frequency. However, at the target disturbance frequency, this could also be due to the pilot using δ_P to "chase" the target (even though he was *instructed not to do so*).

Motion feedthrough evidenced by line spectra at motion disturbance frequencies.

Figure 161. Power Spectra [$\Phi(\omega)$] and Power Fraction [PF(ω)] for Wings Level Turn and Roll Control Inputs

Thumb Button Controller 1.0 Lb Deadband, 3.3 Lb/g Maneuver Gradient
Cooper-Harper 3

rating data indicated that occasionally on retesting of these configurations, large discrepancies in ratings occurred. The air-to-ground task was a dynamic maneuver that was dependent on properly executing the roll-in on the target. An improper roll-in resulted in a much higher level of workload to accomplish the mission. When using only one run to establish the rating, it would be difficult to account for the effect of the roll-in on configuration acceptability. Another potential problem with using only one run is due to the tendency to compare the present configuration with the previous run. If there are significant differences in the configurations, the pilot could be adversely affected by the sudden change. By requiring several runs, the pilot has time to adapt to the configuration change. For these reasons it is recommended that future efforts require multiple runs if the task duration is short and the associated workload is high.



Notes:

* Crosscoupling between controllers suggested by line spectra in Φ_{δ_p} and $\Phi_{\delta_{TBC}}$ at the same frequency. However, at the target disturbance frequency, this could also be due to the pilot using δ_p to "chase" the target (even though he was instructed not to do so).

Motion feedthrough evidenced by line spectra at motion disturbance frequencies.

GP43-0089-114

Figure 162. Power Spectra [Φ(ω)] and Power Fraction [PF(ω)] for Wings Level Turn and Roll Control Input

Thumb Button Controller 1.5 Lb Deadband, 3.3 Lb/g Maneuver Gradient

Cooper-Harper 5

Initially, the pilots were not informed of the characteristics which were being varied. Several of the pilots commented that it would help them to have some idea of what characteristics were being varied. Therefore, it was decided to tell the pilots whether a series of runs was to investigate maneuver gradients or deadband/breakout variations. This had two benefits. Early on it was recognized that the comments for increasing maneuver gradient and increasing deadband/breakout were very similar. By informing the pilots of the type of variations, we could be certain that the pilot was directing his attention and comments to the proper characteristics. In addition, some of the pilots seemed to appreciate being told more about what was going on and were more cooperative as a result.

From the beginning we had planned to use feedback of some type of performance score as a means of stimulating pilot performance. These scores were to be given to the pilot after he had given a pilot rating and associated comments. This would prevent the scores from influencing the pilot rating data. Unfortunately, due to the problems discussed in the task description section, we were unable to implement this procedure until the air-to-air tracking evaluations. For this task, scores consisting of time within 5 and 10 mils of the target were used as the feedback. Pilot response seemed very favorable, with pilots actively requesting the information after each rating. This indicates that the use of performance scores as feedback to stimulate pilot interest and performance is useful and should be considered in future efforts.

In all tasks the pilots were instructed to acquire the target as accurately as possible. No definite specification of desired or adequate performance was given. Pilot ratings were determined by using the Cooper-Harper scale and the pilot's personal standard for desired and acceptable performance to establish a rating for the configuration in the task. It is felt this method worked well in minimizing differences in pilot ability. The better pilots could relax because of "too loose" definitions of adequate and acceptable performance. Those pilots who had more trouble with the tasks were not forced to degrade their ratings due to "too tight" a specification of performance goals. Future efforts should consider this technique as a means of "accounting" for pilot abilities.

b. Lessons on Controller Characteristics - One of the most striking observations made during the early portions of the simulation was the impact controller characteristics could have on the pilot's perception of the aircraft dynamics. The pilots were informed in the presimulation briefing that the aircraft dynamics would be held constant for each task. Only the controller characteristics were varied for each configuration. Still, were an uninformed observer to review the pilot comments, the impression would probably be that the aircraft dynamics were being varied as well as the controller sensitivity and characteristics.

The variation of maneuver gradient was the most significant example. For example, the wings level turn mode was modeled as a first order response with a half second time constant for the air-to-ground tasks. A wide range of maneuver gradients were examined. With the lighter maneuver gradients, the pilot comments generally addressed a lack of damping for the wings level turn response. Typical pilot comments for the higher maneuver gradients addressed things such as a delay and significant lag in the response. Since the mode dynamics were constant, what the pilots were really commenting on was the effect of maneuver gradient variations on the pilot-vehicle closed loop response. Similar comments were observed in all of the simulation tasks.

Another interesting trend was observed in the pilot's comments on deadband/breakout variations. Throughout the simulation, the standard procedure was to perform the maneuver gradient variation first, using a nominal deadband/breakout. From these runs, the preferred maneuver gradient was selected. A variation of the deadband/breakout forces was then conducted using the selected maneuver gradient. Although there were some comments concerning problems with command reversals, the major comments associated with increasing deadband/breakout was an increase in the force required to obtain the desired response. At the extremes of the deadband variations with the twist grip and thumb button, the pilots commented on a perceived delay or lag in the response. The only thing that significantly differentiated the deadband/breakout variation comments from those collected during maneuver gradient variations was the absence of comments on controller sensitivity in the deadband/breakout comments.

From the analysis of the simulation data it appears that maneuver gradient and deadband/breakout forces were interrelated. The procedures used in this simulation were not designed to develop the optimum configuration. As stated in the objectives, the procedures used have served to indicate trends to assist in the development of design guidelines. To develop a true optimum we would recommend using the procedures developed here to find the acceptable region of characteristics. In this region a matrix approach comparing various combinations of controller characteristics could be used to arrive at the optimum combination.

The rudder pedals were the most widely accepted controller examined in this simulation. The use of the pedals appeared natural to the pilots when used to control the wings level turn and fuselage azimuth aiming modes. This was not entirely true when examining the lateral translation mode in the approach and landing tasks. However, the pilots found the lateral translation mode response to be somewhat confusing and unnatural regardless of the controller used.

Several maximum deflection limits were examined on the pedals including one-half, one, two, and three inches. The pilots indicated a preference for the one and two inch pedal throws. These were felt to be near the optimum in terms of speed of input and predictability of response. The shorter throws aided in the speed with which a given command could be reached, while the definite motion of the pedals assisted in determining the predictability of the response. With the wings level turn mode, the one inch throw was appreciated for the rapidity with which the desired heading rate of change could be commanded. The shorter pedal throw resulted in a perceived quickening of the response. For the azimuth aiming mode the two inch deflection resulted in improved predictability of the response.

The twist grip sidestick was generally the second controller the pilots found acceptable. The controller as tested suffered

from two major problems on which the pilots commented. One problem was the shape of the control grip. Several pilots indicated that if the grip were shaped more to facilitate applying torque to the controller without having to grip it very tightly, the controller would have been much more acceptable. The other problem mentioned was the apparent lack of motion when applying twist inputs. The problems associated with isometric controllers are well documented. The pilots felt it would be desirable to experiment with several different torque-rotation gradients for the twist control. The pilots also mentioned the desirability of a hard stop to indicate when full input was applied. In the air-to-ground tasks several pilots commented that they were applying large torque inputs just to insure that full wing level turn command was being applied. This often led to problems with twist inputs coupling into roll rate commands from the sidestick controller. For the azimuth aiming tasks, the controller was usable but lacked the predictability of some of the rudder pedal configurations.

The problems associated with making large, rapid wing level turn command inputs with the thumb button are well documented in the air-to-ground analysis section. The resulting roll command coupling was a major fault of this controller. As noted in the azimuth aiming/air-to-ground task discussion the pilot's thumb seemed to lack the necessary refinement of control input. In the approach and landing task, prolonged inputs with the thumb were found very uncomfortable. One pilot preferred this controller for the wings level turn/air-to-air tracking task. He found that the thumb button was a natural controller for making the necessary fine tuning inputs required. Other pilots in the air-to-air task commented that they found the button more acceptable for that task than it had been for the air-to-ground tasks. This may have been due to the smoother and lower amplitude inputs required in the air-to-air tasks.

The pilot acceptance of the left hand operated thumbwheel in the approach and landing task seems to indicate the acceptability of a controller not mounted on or part of the conventional flight path controllers. This conclusion should be viewed with some caution, however. Simulation of an approach and landing task is probably accomplished at a significantly lower pilot gain and frequency than might be encountered in in-flight experience. The consequences of a mistake in real life tend to influence the pilots control strategy much more than the environment found in any simulation. It should be noted, however, that the use of motion in this simulation was felt to make the pilots much more aware of conditions near touchdown than would be possible in a fixed base environment.

The limited testing of the sidestick heave axis and throttle twist axis using the vertical translation mode led to some apparent conclusions. The twist action of the throttle seems to be an acceptable and natural appearing method of controlling the aircraft. The heave axis of the sidestick, while appearing

natural, placed an additional control task on the pilot's right hand at a critical moment in the task. The force applied to push the stick up or down resulted in a very unnatural feel.

In conclusion, this simulation has accomplished its goals of establishing trends and developing guidelines for the design of several controllers for uncoupled aircraft motion. In addition we have developed procedures which can be used in the design of other controllers not examined in this study. It is recommended that future efforts use the combination of spectral analysis and pilot subjective assessment to define the design. The methods discussed in the spectral analysis section can be used to minimize the effects of motion feedthrough by helping to establish minimum levels of deadband, breakout, etc. The use of pilot subjective assessment will then lead the designer to an acceptable solution in the remaining design space.

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APPENDIX A

LITERATURE SURVEY SUMMARY

LIST OF SYMBOLS AND ABBREVIATIONS

A/A	Air-to-Air
A/G	Air-to-Ground
CCV	Control Configured Vehicle
DLC	Direct Lift Control
IR	Inflight Refueling
LT	Lateral translation
ME	Maneuver enhancement
PST	Post Stall technology
TF	Terrain following
TOL	Takeoff and landing
VIFF	Vectoring in forward flight
VPC	Vertical path control
VT	Vertical translation
δ_{pd}	Rudder pedal deflection
ζ_{SP}	Short period damping
ω_{SP}	Short period frequency

LITERATURE SURVEY

REF. NO.	UNCOUPLED MOTION: LONGITUDINAL	UNCOUPLED MOTION: LATERAL	CLASS OF AIRCRAFT: I	CLASS OF AIRCRAFT: II	CLASS OF AIRCRAFT: III	CLASS OF AIRCRAFT: IV	TYPE OF STUDY: FIXED-BASE SIMULATION	TYPE OF STUDY: MOTION-BASE SIMULATION	TYPE OF STUDY: FLIGHT TEST	MISSIONS INVESTIGATED: TAKEOFF/LANDING	MISSIONS INVESTIGATED: AIR-TO-AIR	MISSIONS INVESTIGATED: AIR-TO-GROUND	MISSIONS INVESTIGATED: INFLIGHT REFUELING	MISSIONS INVESTIGATED: TERRAIN FOLLOWING	CONTROLLERS: CONVENTIONAL	CONTROLLERS: UNCONVENTIONAL	PERFORMANCE EVALUATED	DISPLAYS EVALUATED	WORKLOAD ASSESSMENT	COMMENTS
1			X	X	X	X									X					Basic Controller Parameters
2	X	X													X	X				Apollo Spacecraft Controllers
3						X			X		X	X			X		X		X	Handling Qualities During Tracking Report
4	X			X			X			X					X	X	X	X	X	Direct-Lift-Control on a Transport
5	X					X			X	X					X	X	X			Navion Simulation of DLC. F-8C
6	X					X			X	X					X	X	X		X	Navion Simulation Study
7	X				X	X		X		X			X	X	X	X	X		X	DLC and ME on C-5A and F104.
8		X				X			X			X			X	X	X		X	WLT and LT on NT-33
9		X				X			X			X			X		X	X		NT-33 Simulation of A-9 and A-10 including WLT on A-9
10	X					X			X	X					X	X	X			DLC installed on F-8C
11	X					X	X		X	X					X	X	X			DLC installed on F-8C
12	X					X			X				X		X				X	DLC incorporated on Variable stability F-100C
13		X				X	X	X				X			X	X	X		X	WLT, LT, ME on F-8 aircraft

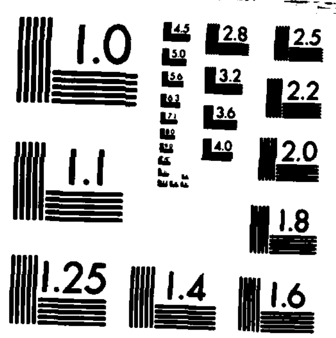
LITERATURE SURVEY

REF. NO.	UNCOUPLED MOTION		CLASS OF AIRCRAFT				TYPE OF STUDY			MISSIONS INVESTIGATED					CONTROLLERS		PERFORMANCE EVALUATED	DISPLAYS EVALUATED	WORKLOAD ASSESSMENT	COMMENTS
	LONGITUDINAL	LATERAL	I	II	III	IV	FIXED-BASE SIMULATION	MOTION-BASE SIMULATION	FLIGHT TEST	TAKEOFF/LANDING	AIR-TO-AIR	AIR-TO-GROUND	INFLIGHT REFUELING	TERRAIN FOLLOWING	CONVENTIONAL	UNCONVENTIONAL				
14		X		X					X	X					X	X			X	LT as an approach aid, both manual and auto
15		X				X	X					X			X	X	X	X	X	WLT, LT, and roll about line-of-sight in dive bombing
16	X	X				X									X	X	X	X	X	Controller/display location evaluation in cockpit design aid
17		X				X		X				X			X		X	X	X	WLT in dive bombing.
18	X	X				X			X		X	X	X	X	X	X	X	X		General Dynamics F-16 CCV Phase IV Report
19	X	X				X			X	X	X	X	X		X	X	X		X	Air Force Flight Test Center F-16 CCV Evaluation Report
20		X				X									X	X	X	X		Centrifuge examination of lateral acceleration effects. AFTI/F-16 controller
21						X									X	X	X	X		Centrifuge examination of lateral acceleration effects. AFTI/F-16 controller
22	X	X				X	X				X				X	X	X	X	X	2 versus 1 MCAIR Vectored Lift Fighter Study

LITERATURE SURVEY

REF. NO.	UNCOUPLED MOTION		CLASS OF AIRCRAFT				TYPE OF STUDY			MISSIONS INVESTIGATED					CONTROLLERS		PERFORMANCE EVALUATED	DISPLAYS EVALUATED	WORKLOAD ASSESSMENT	COMMENTS
	LONGITUDINAL	LATERAL	I	II	III	IV	FIXED-BASE SIMULATION	MOTION-BASE SIMULATION	FLIGHT TEST	TAKEOFF/LANDING	AIR-TO-AIR	AIR-TO-GROUND	INFLIGHT REFUELING	TERRAIN FOLLOWING	CONVENTIONAL	UNCONVENTIONAL				
23	X	X				X											X			Addressees potentially useful 6 DOF applications
24											X									Requirements for weapons systems in air combat
25	X																			Application of PST and VIFF in 1 vs 1 combat

AD-A153 300 CONTROLLER REQUIREMENTS FOR UNCOUPLED AIRCRAFT MOTION 3/6
VOLUME 2(U) MCDONNELL AIRCRAFT CO ST LOUIS MO
K D CITURS SEP 84 AFWAL-TR-84-3060-VOL-2
UNCLASSIFIED F33615-81-C-3605 F/G 1/4 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

LITERATURE SURVEY

REF. NO. 1

TITLE:	MANUAL FLIGHT CONTROL SYSTEM FUNCTIONAL CHARACTERISTICS (IEEE Transactions on Human Factors in Engineering Sept 1963)
AUTHOR(S):	John E. Glenn (Northrop Corp)

CLASS OF AIRCRAFT	TYPE OF STUDY	MISSIONS INVESTIGATED
I ✓ II ✓ III ✓ IV ✓	FIXED BASE N.A. MOTION BASE FLIGHT TEST	TOL A/A N.A. A/G IR TF

UNCOUPLED MOTIONS:	N.A.
CONTROLLERS:	Conventional stick and rudder or any mechanical control system.
DISPLAYS:	N.A.
WORKLOAD ASSESSMENT:	N.A.
PERFORMANCE:	N.A.
COMMENTS:	Reviews characteristics of manual control systems e.g., travel, loads, artificial feel, backlash, flexibility, springback, sensitivity, etc. Good basic work on important areas of controller and control system design.

LITERATURE SURVEY

REF. NO. 2

TITLE: Apollo Experience Report - Crew Station Integration Volume III - Spacecraft Hand Controller Development NASA TN D-7884		
AUTHOR(S): Frank E. Wittler (Lyndon B. Johnson Space Center)		
CLASS OF AIRCRAFT	**TYPE OF STUDY**	**MISSIONS INVESTIGATED**
I **II** **III** **IV**	**FIXED BASE** **MOTION BASE** **FLIGHT TEST**	**TOL** **A/A** **A/G** **IR** **TF**
UNCOUPLED MOTIONS:		
CONTROLLERS: Three-axis sidestick control (roll, pitch and yaw) Three-axis T-handle (x, y, and z translations)		
DISPLAYS:		
WORKLOAD ASSESSMENT:		
PERFORMANCE:		
COMMENTS: Describes evaluation of the Apollo three axis rotation hand controller and the three axis translation controller. Stick force gradients, breakouts, deadbands, and hysterisis are outlined. Rotational controller was a palm pivot pitch, base pivot roll controller with rotation about the z-axis. Translation control was a base pivot T-handle with x, y, and z displacements.		

LITERATURE SURVEY

REF. NO. 3

TITLE: Tracking Test Techniques for Handling Qualities Evaluation (AFFTC-TD-75-1)		
AUTHOR(S): T. R. Twisdale and Capt. D. L. Franklin		
CLASS OF AIRCRAFT	TYPE OF STUDY	MISSIONS INVESTIGATED
I II III IV ✓	FIXED BASE MOTION BASE FLIGHT TEST ✓	TOL A/A ✓ A/G ✓ IR TF

UNCOUPLED MOTIONS: N.A.

CONTROLLERS: N.A.

DISPLAYS: Fixed depressed reticle

WORKLOAD ASSESSMENT: Correlation of pilot inputs to configuration pilot rating.

PERFORMANCE: Pipper motion, RMS pipper error, pipper error time histories, Percentage tracking time vs pipper error, pilot ratings and comments

COMMENTS:
Method of evaluating the pilot-in-the-loop handling qualities of an aircraft in combat oriented tracking maneuvers. Air-to-Air tasks were 1) wind-up tracking turns, 2) constant α turns. Air-to-Ground tasks were 1) 30° dive bomb, 2) 15° strafe. Air-to-Ground tasks not validated, Air-to-Air task provided good quantitative handling-qualities data when combined with pilots ratings and comments.

LITERATURE SURVEY

REF. NO. 4

TITLE: FIXED-BASE SIMULATOR STUDY OF AN EXTERNALLY BLOWN FLAP STOL TRANSPORT AIRPLANE DURING APPROACH AND LANDING (NASA TN D-6898)		
AUTHOR(S): W. D. Grantham, L. T. Nguyeh, J. M. Patton, Jr., P. L. Deal, R. A. Champine, and C. R. Carter		
CLASS OF AIRCRAFT	**TYPE OF STUDY**	**MISSIONS INVESTIGATED**
I II ✓ III IV	✓ FIXED BASE MOTION BASE FLIGHT TEST	TOL ✓ A/A A/G IR TF
UNCOUPLED MOTIONS: Direct Life Control		
CONTROLLERS: Thumbwheel mounted on top of right horn of the control yoke.		
DISPLAYS: Flight Director Analog dial indicating percent DLC authority commanded		
WORKLOAD ASSESSMENT: Reduced necessity for pilot making small thrust changes with the throttle.		
PERFORMANCE: Pilot ratings and comments were collected. DLC improved rating from 2.5 to 2.0.		
COMMENTS: Aircraft was operating on backside of thrust curve with an auto-speed control using flaps to maintain constant airspeed. In this configuration, flight path is controlled by the throttles. The DLC control was a vernier throttle control for modulating small changes in thrust.		

LITERATURE SURVEY

REF. NO. 5

TITLE: FLIGHT EVALUATION OF DIRECT LIFT CONTROL AND ITS EFFECTS ON HANDLING QUALITIES IN CARRIER APPROACH (PRINCETON U. (AMS) RPT 811)		
AUTHOR(S): Herman A. Mooij		
CLASS OF AIRCRAFT	TYPE OF STUDY	MISSIONS INVESTIGATED
I II III IV ✓	FIXED BASE MOTION BASE ✓ FLIGHT TEST	TOL ✓ A/A A/G IR TF
Aircraft was Princeton variable-stability Navion configured to simulate USN F-8C in landing approach.		
UNCOUPLED MOTIONS: Manuever enhancement (ME) Direct lift control (DLC)		
CONTROLLERS: Center Stick (ME) Spring loaded 3-position switch (bang-bang DLC) Center loaded thumbwheel (proportional DLC)		
DISPLAYS: N.A.		
WORKLOAD ASSESSMENT:		
PERFORMANCE: Cooper ratings and Pilot Comments that both ME and DLC improve landings over conventional control.		
COMMENTS: Both modes improved approach. DLC was especially liked close-in since it gave altitude control without changing pitch attitude.		

LITERATURE SURVEY

REF. NO. 6

TITLE: FLIGHT EVALUATION OF ENGINE RESPONSE, FLIGHT PATH STABILITY, TAIL LIFT, AND DIRECT LIFT CONTROL (Princeton U. (AMS) RPT-888)		
AUTHOR(S): G. E. Miller; R. L. Traskos		
CLASS OF AIRCRAFT	**TYPE OF STUDY**	**MISSIONS INVESTIGATED**
I II III IV ✓	FIXED BASE MOTION BASE ✓ FLIGHT TEST	TOL ✓ A/A A/G IR TF
Aircraft was Princeton Variable-Stability Navion		
UNCOUPLED MOTIONS: Direct-Lift-Control		
CONTROLLERS: Thumbwheel mounted on control stick		
DISPLAYS: N.A.		
WORKLOAD ASSESSMENT: DLC reduced need for making power correction in the close-in part of the approach.		
PERFORMANCE: Cooper ratings and pilot comments used to show improvements in approach due to DLC, especially in low ω_{SP} configurations.		
COMMENTS: DLC investigation was only small part of this in-flight investigation. Impetus for Princeton U. (AMS) RPT-888 investigation come from earlier report 811.		

LITERATURE SURVEY

REF. NO. 7

TITLE: Study and Simulation Program to Investigate the Mechanization of an Aircraft Flight Control System that Employs Direct Lift AFFDL-TR-68-69		
AUTHOR(S): T. W. Chase, V. L. Falkner, R. F. Helfinstine (Honeywell, Inc.)		
CLASS OF AIRCRAFT	**TYPE OF STUDY**	**MISSIONS INVESTIGATED**
I II III ✓ IV ✓	FIXED BASE ✓ MOTION BASE FLIGHT TEST	✓ TOL A/A A/G ✓ IR ✓ TF
Aircraft dynamics were those of C-5A and an F-104.		
UNCOUPLED MOTIONS: Maneuver Enhancement (open loop and closed loop) Direct Lift Control		
CONTROLLERS: Center Stick (ME) Collective type handle, left hand operated (DLC)		
DISPLAYS: Standard set with flight director		
WORKLOAD ASSESSMENT: Pilot comments used to access workload.		
PERFORMANCE: Cooper ratings with pilot comments and computed mean values of several parameters (i.e., stick pos. and N_z)		
COMMENTS: Maneuver enhancement evaluated as beneficial in all flight phases investigated. Simulator was a modified Link motion simulator. Mechanization problems in center stick caused PIO and cast some doubts on simulation results. Direct lift control not liked due to implementation method, loss of throttle control while making DLC inputs.		

LITERATURE SURVEY

REF. NO. 8

TITLE: A FLIGHT TEST INVESTIGATION OF DIRECT SIDE FORCE CONTROL (AFFDL-TR-71-106)		
AUTHOR(S): G. Warren Hall (Cornell Aero. Lab.)		
CLASS OF AIRCRAFT	**TYPE OF STUDY**	**MISSIONS INVESTIGATED**
I II III IV ✓	FIXED BASE MOTION BASE ✓ FLIGHT TEST	TOL A/A A/G ✓ IR TF
Aircraft was USAF variable-stab. T-33 using wing mounted drag petals and rudder to generate side force.		
UNCOUPLED MOTIONS: Wings-Level-Turn (.5°/sec) Lateral translation (31 ft/sec)		
CONTROLLERS: Stick mounted thumb wheel (not spring loaded) Aileron stick with automatic roll stabilization Rudder pedals		
DISPLAYS: N.A.		
WORKLOAD ASSESSMENT: Wings level turn reduced workload in acquiring target since only one input needed rather than two bank to turn inputs.		
PERFORMANCE: More authority needed. Wings level turn increased pilots ability to acquire and hold target.		
COMMENTS: Pilots liked idea of separate control for uncoupled motion however thumb wheel as mechanized was not acceptable. Rudder pedals preferred over stick since stick requires roll stabilization. Pilots liked ability to select/deselect side force control as desired by a spring loaded switch on stick.		

LITERATURE SURVEY

REF. NO. 9

TITLE: AN IN-FLIGHT INVESTIGATION OF THE INFLUENCE OF FLYING QUALITIES ON PRECISION WEAPONS DELIVERY (AFFDL-TR-72-120)		
AUTHOR(S): G. Warren Hall and Normal C. Weingarten (Cornell Aeronautical Laboratory)		
CLASS OF AIRCRAFT	**TYPE OF STUDY**	**MISSIONS INVESTIGATED**
I II III IV ✓	FIXED BASE MOTION BASE ✓ FLIGHT TEST	TOL A/A A/G ✓ IR TF
Aircraft was USAF/CAL Variable Stability NT-33 simulating the A-10A and A-9A aircraft with variations in handling qualities.		
UNCOUPLED MOTIONS: Wings level turn on the A-9A aircraft		
CONTROLLERS: Rudder pedals for WLT		
DISPLAYS: Fixed, depressed reticle on Head Up Display		
WORKLOAD ASSESSMENT: N.A.		
PERFORMANCE: Once learned, WLT improved accuracy in both dive bombing and strafing. Improvement most obvious with strafing.		
COMMENTS: WLT had limited authority, used to cancel small errors. Missions were 25° dive bombing and 15° dive strafing. ·Rudder pedal break out force, force gradient, and hysteresis were varied. Good discussion of ground attack performance measures. (i.e., CEP, REP, DEP).		

LITERATURE SURVEY

REF. NO. 10

TITLE: EVALUATION OF THE DIRECT LIFT CONTROL SYSTEM INSTALLED IN THE F-8C AIRPLANE (NATC FT-51R-65)		
AUTHOR(S): Lt. R. T. Gralow, USN Lt. J. D. Peace, USN J. L. Shipley		
CLASS OF AIRCRAFT	**TYPE OF STUDY**	**MISSIONS INVESTIGATED**
I II III IV ✓	FIXED BASE MOTION BASE ✓ FLIGHT TEST	TOL ✓ A/A A/G IR TF
Mission investigated was use of DLC in carrier approach.		
UNCOUPLED MOTIONS: Direct-Lift-Control (DLC)		
CONTROLLERS: Spring loaded wheel switch mounted on stick grip		
DISPLAYS: N.A.		
WORKLOAD ASSESSMENT: N.A.		
PERFORMANCE: Cooper ratings, approach speed and sink rate error, and touchdown dispersion used to show improvement due to DLC.		
COMMENTS: Define improvement in landing using DLC. Report recommended incorporation of DLC on all fleet F-8 aircraft. As installed, DLC resulted in slight degradation of lateral control.		

LITERATURE SURVEY

REF. NO. 11

TITLE:	DIRECT LIFT CONTROL AS A LANDING APPROACH AID IN THE F-8C AIRPLANE-SIMULATOR AND FLIGHT TEST (LTV RPT 2-53310/4R-175)
AUTHOR(S):	J. D. Etheridge, F. W. Prilliman, G. T. Upton, C. E. Mattlage

CLASS OF AIRCRAFT	TYPE OF STUDY	MISSIONS INVESTIGATED
I II III IV ✓	✓ FIXED BASE MOTION BASE ✓ FLIGHT TEST	TOL ✓ A/A A/G IR TF

Documents system design and checkout of USN F-8C Direct Lift Control aircraft by Ling-Temco-Vought

UNCOUPLED MOTIONS:	Direct Lift Control
CONTROLLERS:	Spring center wheel (knob) on control stick (provide proportional or full on-off at pilots selection)
DISPLAYS:	N.A.
WORKLOAD ASSESSMENT:	N.A.
PERFORMANCE:	Flight path errors and touchdown dispersion use to validate improvement due to DLC.
COMMENTS:	More rapid means of controlling altitude than normal longitudinal control. DLC allows flight path corrections near touchdown that could not be made by a 'normal' aircraft due to attitude constraints on carrier landings.

LITERATURE SURVEY

REF. NO. 12

TITLE:	A FLIGHT STUDY OF THE USE OF DIRECT-LIFT-CONTROL FLAPS TO IMPROVE STATION KEEPING DURING IN-FLIGHT REFUELING (NASA TM X-2936)
AUTHOR(S):	W. E. McNeill, R. M. Gerdes, R. C. Innis, J. D. Ratcliff

CLASS OF AIRCRAFT	TYPE OF STUDY	MISSIONS INVESTIGATED
I II III IV ✓	FIXED BASE MOTION BASE ✓ FLIGHT TEST	TOL A/A A/G IR ✓ TF

Aircraft was variable-stability F100C using symmetrical aileron deflection with elevator interconnect

UNCOUPLED MOTIONS:	Direct Lift (However pilot comments indicate it may have acted like a maneuver enhancement control)
CONTROLLERS:	Implemented through normal control stick
DISPLAYS:	N.A.
WORKLOAD ASSESSMENT:	DLC reduced control activity over unaugmented aircraft control activity for the same task.
PERFORMANCE:	
COMMENTS:	Three systems tested 1) unaugmented $\zeta_{SP} = 0.22$; 2) pitch damper $\zeta_{SP} = 0.75$; 3) DLC added to '1)'. Little difference was found between 2) and 3). Both improved station keeping ability over configuration 1).

LITERATURE SURVEY

REF. NO. 13

TITLE: An Investigation of the Potential Benefits of Direct Sideforce Control from a Mission Viewpoint (Boeing Co., D180-17508-1)		
AUTHOR(S): E. Frank Carlson		
CLASS OF AIRCRAFT	**TYPE OF STUDY**	**MISSIONS INVESTIGATED**
I **II** **III** **IV** ✓	✓ **FIXED BASE** ✓ **MOTION BASE** **FLIGHT TEST**	**TOL** **A/A** **A/G** ✓ **IR** **TF**
Simulated airplane was on F-8 equipped with sideforce generators. Simulators were the NASA FSAA motion base and Boeing MSS fixed base.		
UNCOUPLED MOTIONS: Wings-level-turn (WLT) Lateral translation (LT) Lateral maneuver enhancement (ME)		
CONTROLLERS: Rudder pedals (WLT) Throttle mounted finger controller (LT) Conventional center stick (ME)		
DISPLAYS: N.A.		
WORKLOAD ASSESSMENT: Not addressed directly. Point is made that heading change using WLT requires only 1 input while conventional heading change is a multiloop control requiring 2 inputs.		
PERFORMANCE: CEP's, pilot comments, comparative time histories		
COMMENTS: Simulation results indicate direct side force controls improved dive bombing weapons delivery by a factor of 3 over conventional control. Pilots felt they could easily adapt to $\pm 1N_y$ lateral accelerations. Pilots felt DSFC reduced pilot workload in bombing task while increasing survivability by allowing higher approach speeds with jinking to lower altitudes. Uses also indicated for inflight refueling and crosswind landings.		

LITERATURE SURVEY

REF. NO. 14

TITLE: DIRECT SIDE FORCE CONTROL (DSFC) FOR STOL CROSSWIND LANDINGS (AFFDL-TR-73-2)

AUTHOR(S): Edward M. Booth and Howard J. Ledder (Calspan Corp.)

CLASS OF AIRCRAFT	TYPE OF STUDY	MISSIONS INVESTIGATED
I	FIXED BASE	TOL ✓
II ✓	MOTION BASE	A/A
III	✓ FLIGHT TEST	A/G
IV		IR
		TF

Aircraft was Calspan operated Total-Inflight Simulator (TIFS)

UNCOUPLED MOTIONS: Lateral translation

CONTROLLERS: Thumbwheels mounted on control wheel and throttle. Also, automated implementation on ILS localizer beam.

DISPLAYS: N.A.

WORKLOAD ASSESSMENT: Automatic DSFC relived pilot of lateral-direction task.

PERFORMANCE:

COMMENTS: Thumb wheels provided proportional control of lateral velocity. DSFC provided improved Cooper-Harper ratings over conventional control. Automatic implementation was liked however implementation problems resulting in poor runway alignment reduced effectiveness.

LITERATURE SURVEY

REF. NO. 15

TITLE: AFFDL-TR-76-78 DIRECT SIDE FORCE CONTROL CRITERIA FOR DIVE BOMBING		
AUTHOR(S): Brulle, R. W., Moran, W. A., Marsh, R. G. (McDonnell Aircraft)		
CLASS OF AIRCRAFT	TYPE OF STUDY	MISSIONS INVESTIGATED
I II III IV ✓	FIXED BASE ✓ MOTION BASE FLIGHT TEST	TOL A/A A/G ✓ IR TF
UNCOUPLED MOTIONS: 1. Wings - level- turn 2. Lateral Translation 3. Roll about weapon delivery line-of-sight		
CONTROLLERS: 1. Stick mounted thumb isometric 2. Rudder pedals		
DISPLAYS: HUD with fixed, velocity vector, and future-impact-point sights		
WORKLOAD ASSESSMENT: Techniques include describing function analysis, tracking error and control motion.		
PERFORMANCE: Wings-level-turn mode improved accuracy over conventional aircraft		
COMMENTS: Recommends 1g lateral acceleration. Rudder Pedals preferred. Recommends future investigation use WLT with Lateral translation proportional rudder pedal mechanization.		

LITERATURE SURVEY

REF. NO. 16

TITLE:	High Acceleration Cockpit Controller Locations AFFDL-TR-75-58
AUTHOR(S):	R. E. Mattes, C. F. Asiala, S. L. Loy McDonnell Aircraft

CLASS OF AIRCRAFT	**TYPE OF STUDY**	**MISSIONS INVESTIGATED**
I II III IV ✓	**FIXED BASE** **MOTION BASE** **FLIGHT TEST** ✓ COCKPIT DESIGN AID	**TOL** **A/A** **A/G** **IR** **TF**

Test facility was a cockpit mockup for an advanced fighter incorporating a high acceleration cockpit (HAC)

UNCOUPLED MOTIONS: Unspecified Direct Lift and Side Force modes
Fuselage elevation and azimuth pointing.

CONTROLLERS: Stick mounted isometric

DISPLAYS: HUD
CRT's

WORKLOAD ASSESSMENT: Not related to direct-force modes. Time to complete a task was used to evaluate cockpits.

PERFORMANCE: Pilot comments and time to respond used to evaluate several cockpit/controller/MAC configurations.

COMMENTS: This was not a simulation. Rather it was an effort to define cockpit geometry and sidestick controller position to incorporate a high acceleration seat. Some mention of tradeoffs for direct force and trim functions.

LITERATURE SURVEY

REF. NO. 17

TITLE: FLYING-QUALITIES CRITERIA FOR WINGS-LEVEL-TURN MANEUVERING DURING AN AIR-TO-GROUND WEAPON-DELIVERY TASK (NASA TM 8 1266)		
AUTHOR(S): R. I. Sammonds and J. W. Bunell		
CLASS OF AIRCRAFT	**TYPE OF STUDY**	**MISSIONS INVESTIGATED**
I II III IV ✓	FIXED BASE ✓ MOTION BASE FLIGHT TEST	TOL A/A A/G ✓ IR TF
Six-degree-of-freedom Flight Simulator for Advanced Aircraft (FSAA) at Ames Research Center was used.		
UNCOUPLED MOTIONS: Wings-level-turn		
CONTROLLERS: Rudder Pedals		
DISPLAYS: Head-Up-Display with reticle, pitch ladder, altitude, velocity, and release condition indicators.		
WORKLOAD ASSESSMENT: Pilots felt wings-level-turn greatly simplified the lateral tracking task and allowed more attention to be devoted to longitudinal task in comparison to bank-to-turn aircraft.		
PERFORMANCE: Improved flying qualities in comparison to conventional aircraft.		
COMMENTS: Task was a supersonic dive bombing run with a primary and secondary target. The task was defined to be extremely difficult in order to high-lite system difficulties. Parametric examination of Ay/δ_{Pd} frequency and damping. Secondary target task was almost impossible without high authority WLT.		

LITERATURE SURVEY

REF. NO. 18

TITLE: FIGHTER CCV PHASE IV REPORT (AFFDL-TR-78-9)		
AUTHOR(S): J. D. McAllister, et al General Dynamics Corp., Fort Worth Div.		
CLASS OF AIRCRAFT	**TYPE OF STUDY**	**MISSIONS INVESTIGATED**
I II III IV ✓	FIXED BASE MOTION BASE ✓ FLIGHT TEST	TOL A/A ✓ A/G ✓ IR ✓ TF ✓
Aircraft was YF-16 CCV		
UNCOUPLED MOTIONS: Vertical path control, wings level turn, fuselage elevation and azimuth pointing, vertical translation, lateral translation, maneuver enhancement.		
CONTROLLERS: VPC, WLT, aiming, translation - isometric button mounted in stick. WLT, azimuth aiming, lat translation-rudder pedal M.E.-normal stick		
DISPLAYS: lateral accelerometer, left-and right-hand flaperon, canard position, and rudder position indicators. CCV disconnect caution light and a Max CCV command light.		
WORKLOAD ASSESSMENT: N.A.		
PERFORMANCE: Handling-Qualities-During-Tracking data used to quantitatively measure improvements due to CCV. Pilot comments and some pilot ratings give qualitative data.		
COMMENTS: Basic recommendations were: Air-to-Ground (in order of importance) 1. Wings-Level-Turn 3. Maneuver enhancement 5. Pointing Modes 2. Vertical path cont 4. Lateral translation Air-to-Air (in order of importance) 1. Maneuver enhancement 4. Translation modes 2. Vertical-path-control 5. Manual pointing 3. Wings-level-turn		

LITERATURE SURVEY

REF. NO. 19

TITLE: YF-16 CONTROL CONFIGURED VEHICLE (CCV) OPERATIONAL POTENTIAL, FLYING QUALITIES, AND PERFORMANCE EVALUATION (AFFTC-TR-77-23)		
AUTHOR(S): R. A. WOOD, M. P. GARLAND, E. T. MESCHKO		
CLASS OF AIRCRAFT	**TYPE OF STUDY**	**MISSIONS INVESTIGATED**
I II III IV ✓	FIXED BASE MOTION BASE ✓ FLIGHT TEST	TOL ✓ A/A ✓ A/G ✓ IR ✓ TF
UNCOUPLED MOTIONS: Vertical Path Control, Vertical Translation, Fuselage elevation aiming, Lateral Translation, Wings-Level-Turn, Fuselage azimuth aiming		
CONTROLLERS: Conventional (maneuver enhancement) Trim-type button (all) Rudder pedal (Lateral modes)		
DISPLAYS:		
WORKLOAD ASSESSMENT: CCV modes require fewer control inputs by pilots to perform some tasks.		
PERFORMANCE: Demonstrated potential for imporving accomplishment of nearly all fighter operational tasks.		
COMMENTS: Mentions limited authority available, some of the benefits are based on extrapolation ot higher levels of authority and task optimized controller characteristics. Offers several suggestions for future studies.		

LITERATURE SURVEY

REF. NO. 20

TITLE: Interim Report - Investigation of the Effects of Gy and G_z on AFTI/F-16 Control Inputs, Restraints, and Tracking Performance for AFWAL/FIT by AFAMRL/BBS

AUTHOR(S): R. E. Van Patten
J. W. Frazier

CLASS OF AIRCRAFT	TYPE OF STUDY	MISSIONS INVESTIGATED
I II III IV ✓	FIXED BASE MOTION BASE FLIGHT TEST ✓ CENTRIFUGE	TOL A/A A/G IR TF

UNCOUPLED MOTIONS: Wings-level-turn

CONTROLLERS: AFTI/F-16 sidestick and throttle with pitch pointing rudder pedals mechanized for yaw control.

DISPLAYS: Video HUD with altitude, velocity, and pitch 50 mil pipper and target

WORKLOAD ASSESSMENT: N.A.

PERFORMANCE: Tracking scores, control inputs to off axis, Analysis of variance applied to tracking scores.

COMMENTS:
Both open loop (constant) and closed loop (pilot controlled) combinations of N_z and N_y during a tracking task. Addresses need for improved lateral acceleration pilot restraints. Identifies several potential control cross-coupling problems in the throttle pitch pointing, roll, pitch and yaw controls due to combinations of N_z and N_y. Several recommendations for future 6 DOF designs.

LITERATURE SURVEY

REF. NO. 21

TITLE: Evaluation of AFTI/F-16 Restraint Concepts in the $\pm 2G_y$ Environment (AFAMRL-TR-8-130)

AUTHOR(S): R. E. Van Patten, J. W. Frazier, D. W. Repperger and D. B. Rogers

CLASS OF AIRCRAFT	TYPE OF STUDY	MISSIONS INVESTIGATED
I	FIXED BASE	TOL
II	MOTION BASE	A/A
III	FLIGHT TEST	A/G
IV ✓	✓ CENTRIFUGE	IR
		TF

Simulation was of AFTI/F-16 conventional restraints and proposed shoulder pads during lateral tracking while exposed to various levels of N.

UNCOUPLED MOTIONS:

N.A. (open loop Gy)

CONTROLLERS: AFTI/F-16 sidestick and throttle using lateral stick inputs to track target

DISPLAYS: Video display representing 50 mil pipper with target moving laterally.

WORKLOAD ASSESSMENT:

N.A.

PERFORMANCE: Pilot comment and tracking scores with and without restraints.

COMMENTS:

± 1Ny seemed to have little effect on tracking.
± 1Ny did not indicate a need for shoulder restraint.
± 2Ny degraded tracking performance
± 2Ny tracking scores were better with restraints
-2Ny most severe condition
Restraints need optimized. Must allow movement and not block access to side panels
Significant control cross coupling in both stick and rudder

LITERATURE SURVEY

REF. NO. 22

TITLE: SIMULATION ANALYSIS: UNORTHODOX CONTROL FORCE FIGHTER AIRCRAFT

AFWAL-TR-80-3060

AUTHOR(S): A. R. Mitchell, T. A. Halley, J. M. Roedder (McDonnell Aircraft)

CLASS OF AIRCRAFT	TYPE OF STUDY	MISSIONS INVESTIGATED
I II III IV ✓	✓ FIXED BASE MOTION BASE FLIGHT TEST	TOL A/A ✓ A/G IR TF

UNCOUPLED MOTIONS: Maneuver Enhancement (Long. and Lat.) Drag Modulation, Coupled Fuselage Pointing, Wing-Level-Turn, Direct-Lift, Direct-Side-Force

CONTROLLERS: Center stick (ME)
Stick mounted isometric thumb controller
Automatic pointing coupled to fire control system

DISPLAYS: Heads up display with normal information plus an authority box for the coupled fuselage aiming mode authority

WORKLOAD ASSESSMENT: Workload not mentioned specifically. Inferences can be drawn from increased time on advantage.

PERFORMANCE: Defines parameters T* (Offense-Defense Engagement Control Time), $\hat{\theta}$, $\hat{\phi}$, (steering and rolling Engagement penalty functions) as well as normal exchange ratios and radar tracking time.

COMMENTS:

2 versus 1 simulation of the MCAIR Vectored Lift Fighter (VLF) featuring improved high angle of attack rolling agility and PST (post stall technology). A fire control fuselage pointing mode and manual direct force modes are included. A distinct improvement in time on advantage and exchange ratio was noted for the VLF.

LITERATURE SURVEY

REF. NO. 23

TITLE: Review of Practical Experience On Combat Aircraft Maneuverability AGARD Flight Mechanics Panel Symposium, October 1981		
AUTHOR(S): Maj. A. W. Henni, RNAF		
CLASS OF AIRCRAFT	**TYPE OF STUDY**	**MISSIONS INVESTIGATED**
I II III IV	FIXED BASE MOTION BASE FLIGHT TEST	TOL A/A A/G IR TF
UNCOUPLED MOTIONS:		
CONTROLLERS:		
DISPLAYS:		
WORKLOAD ASSESSMENT:		
PERFORMANCE:		
COMMENTS: Pilots viewpoint. Sees the following as potentially useful 6 DOF applications. (1) enhanced instantaneous pitch rates in terrain avoidance (2) direct lift for altitude control in terrain avoidance (3) direct side force for wings level turn in terrain avoidance (4) enhanced maneuverability in general in target acquisition (ground attack) (5) improved low speed jinking, especially with external stores (6) improved accuracy for unguided weapons General conclusion: maneuverability will continue to be a valuable asset in fighter mission (evidenced by fact that neither IR nor radar missiles have negated need for close-in combat capability).		

LITERATURE SURVEY

REF. NO. 24

TITLE: Airframe and Weapon Requirements in Air Engagements AGARD Flight Mechanics Panel Symposium, October 1981		
AUTHOR(S): J. E. Rossiter, RAE, Farnborough, UK		
CLASS OF AIRCRAFT	TYPE OF STUDY	MISSIONS INVESTIGATED
I II III IV	FIXED BASE MOTION BASE FLIGHT TEST	TOL A/A A/G IR TF
UNCOUPLED MOTIONS:		
CONTROLLERS:		
DISPLAYS:		
WORKLOAD ASSESSMENT:		
PERFORMANCE:		
COMMENTS: Brief Summary of Systems Assessment Department (SAD) results at RAE Farnborough. Maneuverability (i.e., maximum turn rate) is needed mostly in 1 vs 1 combat, which only occurs if long range identification and attack are not possible.		

LITERATURE SURVEY

REF. NO. 25

TITLE: Assessing the Operational Effectiveness of Unconventional Maneuver Modes
AGARD Flight Mechanics Panel Symposium, October 1981

AUTHOR(S):
J. V. Goodfellow, RAE, Farnborough, UK

CLASS OF AIRCRAFT	TYPE OF STUDY	MISSIONS INVESTIGATED
I II III IV	FIXED BASE MOTION BASE FLIGHT TEST	TOL A/A A/G IR TF

UNCOUPLED MOTIONS:

CONTROLLERS:

DISPLAYS:

WORKLOAD ASSESSMENT:

PERFORMANCE:

COMMENTS: Summarizes non-real-time simulations of Post-Stall Technology (PST) and Thrust Vectoring in Forward Flight (VIFF). Identified five situations in which PST or VIFF would be clearly beneficial - all involve the need for rapid deceleration in 1 vs 1 combat.

APPENDIX B

REQUEST FOR INFORMATION

DEPARTMENT OF THE AIR FORCE
AIR FORCE WRIGHT AERONAUTICAL LABORATORIES (AFSC)
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433

REPLY TO ATTN OF: FIGC (T. Cord)

SUBJECT: Six-Degree-of-Freedom Controller Research Effort

TO:

1. The Air Force Wright Aeronautical Laboratory is sponsoring a study, "Development of Controller Requirements for Uncoupled Aircraft Motion." This will be performed by McDonnell Aircraft Company of St. Louis, MO. with Systems Technology Incorporated, of Hawthorne, California, as subcontractor, in a 28-month study which began 1 August 1981.

2. The objective of this effort is to develop design criteria and gather appropriate substantiating data for cockpit control devices for 6 DOF motion which will assure compatibility among the pilot, the control device(s) and the aircraft response and will thus allow efficient implementation of the 6 DOF control capability and improved mission performance. The intent is to establish general trends for specification of controller characteristics, rather than optimize a specific design. The results will apply over the range of aircraft classes and tasks where uncoupled, 6 DOF motion is of benefit.

3. The effort is divided into two phases. Phase I consists of defining existing data on the design of cockpit controllers of 6 DOF motion and on the application of 6 DOF motion to Air Force mission requirements. Much of the existing data is on helicopter and V/STOL, but this effort is directed at conventional aircraft. Preliminary criteria will be defined at this time. Experiment design (i.e., ground-based simulation using FDL Flight Simulation Facility) and hardware requirement will then be formulated and test plans developed to gather test data necessary to augment existing information. After review and approval, the second phase will be to acquire hardware, conduct tests and formulate the criteria in a form suitable for inclusion into the MIL-Standard, "Flying Qualities of Air Vehicles" and the supporting Handbook.

4. One purpose of this letter is to acquaint aircraft and control system manufacturers with this study, since ultimately the criteria developed will affect their products. Another purpose is to ensure that the study accounts for the lessons learned by manufacturers and research groups. Enclosed are preliminary copies of controller/controlled mode and mission/controlled mode matrices which will be used in determining the types of hardware and tasks to be used. The validity of any of the criteria will depend on the use of proper hardware and the correct simulation tasks. We would welcome your comments on their structure and contents. This letter will be followed by a telephone conversation with MCAIR or STI personnel.

5. Additionally, experience with and the availability of, actual controller or uncoupled motion control systems is of particular interest. Proprietary rights will be protected if required. In return interim reports will be made available to interested organizations as the study progresses.

6. Interested organizations should contact Tom Cord/FIGC/1-513-255-5676 or Lt Dan Basehore/FIGR/1-513-255-4608. Note that this letter does not constitute an offer to purchase services or equipment.

Vernon O. Hoehne

VERNON O. HOEHNE
Asst. Branch Chief
Control Dynamics Branch
Flight Control Division

1 Atch
Background and Matrices

BACKGROUND AND MATRICES

The following matrices are presented for your review and to serve as a basis for future contacts. Comments and suggestions will be considered when selecting hardware and simulation tasks to be utilized.

Some explanations and definitions are appropriate:

Controlled Modes

Mode as used herein defines the type of aircraft response to a commanded input by the pilot. Current plans call for the use of "pure" responses, i.e., no cross couplings. While such a response may not a attainable in actual flight, vigorous investigation of all the possible couplings that could occur would be beyond the scope of this study to examine. Favorable coupling could be used to increase the bandwidth of a mode if required for pilot acceptance. Most of these modes have been examined in ground-based or inflight simulations. The controller/controlled mode matrix breaks each mode into two possible commanded variables.

Conventional aircraft control is achieved by controlling the moments about three axes (roll, pitch and yaw) and the force along the body axis (thrust modulation). Motion in the two remaining axes is achieved by using the airframe response to moments controllable by the pilot, such as bank-to-turn, lift due to angle of attack, and side force due to sideslip. Control vertical and lateral axes. These additional degrees of freedom provide several new control modes. These added modes are:

Longitudinal Modes

- o Vertical path control - Normal load factor (vertical acceleration control) at constant angle of attack.

- o Vertical translation - Vertical acceleration/velocity control at constant attitude.

- o Drag Modulation - Velocity control at a constant thrust setting.

- o Maneuver Enhancement - Blending of conventional and either Vertical path control or Vertical translation to provide quicker response and/or improved ride quality.

Lateral Modes

- o Lateral translation - Lateral acceleration/velocity control without yaw rotation or roll motion.

- o Wings level turn - Heading change control with no sideslip or roll attitude motion.
- o Fuselage azimuth aiming - Sideslip angle control with no lateral load factor.
- o Forward slip - Generation of sideslip at constant flight path direction.

<u>Controllers</u>

The controllers shown in the matrices have all been tried in various ground-based and inflight simulation. However, little was done on determining optimal, or even adequate, controller characteristics.

<u>Tasks</u>

Initial results from mission analysis indicate that these mission tasks are viable for future aircraft and may benefit from the addition of unconvetional motion capability. For those tasks involving weapon delivery, further analysis will be required to determine effects of systems such as the Integrated Flight/Fire Control (IFFC) system and similar programs.

Each matrix element contains either a number or a dash. The numbers indicate current levels or priority assigned to that combination. A '5' indicates high priority while a '1' indicates lower priority. The dash indicates that the combination is not considered compatible or appropriate.

We welcome any comments on the modes, tasks or controllers listed in these matrices. Once refined, these matrices will be used in defining the elements of our simulation test matrix.

TASK/CONTROLLED-MODE MATRIX: LONGITUDINAL

TASK	MODE					
	CONVENTIONAL	DRAG MOD.	VERTICAL PATH CONTROL	VERTICAL TRANSLATION	FUSELAGE AIMING	MANEUVER ENHANCEMENT
Air Combat	5	5	3	-	5	5
Formation	5	5	1	5	-	5
Refueling	5	5	1	5	-	5
Coupled Fire-Flight	-	-	-	-	5	5
En-Route Maneuvers	5	2	2	4	-	5
Bombing	5	3	5	2	-	5
Strafing	5	1	3	1	5	5
Landing (Manual)	5	0	3	5	-	5
Landing (Instrument)	5	-	3	5	-	5

CONTROLLER/CONTROLLED-MODE MATRIX: LATERAL

CONTROLLER	MODE									
	FORWARD SLIP		LATERAL TRANSLATION		WINGS LEVEL TURN		FUSELAGE AIMING		CONVENTIONAL BANK	
	$\dot{\phi}$	ϕ	$\ddot{y}$	$\dot{y}$	$\dot{\phi}$	ϕ	$\dot{\phi}$	ϕ	$\dot{\phi}$	ϕ
Rudder Pedal (Normal Function Disconnected)	-	-	-	3 2 4	3 2 5	-	3 2 5	-	-	-
Stick Mounted Button	-	-	-	2 4	2 4	-	2 4		-	-
Stick Mounted Thumbwheel	-	-	-	3	-	-	-	-	-	-
Conventional Stick	5	3	-	3	-	-	-	-	5	5
Stick Mounted Twist Grip	-	-	-	-	5	-	5	-	-	-
Stick Mounted Thumb Lever	-	-	-	2	5	-	5	-	-	-
Thrust Vector Control Blended with Normal Functions	-	-	-	-	-	-	-	-	-	-
Throttle Mounted Controllers	-	-	-	1	1	-	1	-	-	-
Brake Pedals	-	-	-	4	5	-	5	-	-	-
Automatic Implementation on ILS Localizer	2	-	-	5	-	-	-	-	-	-

TASK/CONTROLLED-MODE MATRIX: LATERAL

TASK	MODE				
	FORWARD SLIP	LATERAL TRANSLATION	WINGS LEVEL TURN	FUSELAGE AIMING	CONVENTIONAL BANK
Air Combat	3	3	5	5	5
Formation	-	5	3	-	5
Refueling	-	5	-	-	5
Coupled Fire-Flight	-	-	-	5	5
En-Route Maneuvers	-	1	5	-	5
Bombing	-	4	5	-	5
Strafing	-	-	3	5	5
Landing (Manual)	4	4	5	-	5
Landing (Instrument)	-	5	5	-	5

CONTROLLER/CONTROLLED-MODE MATRIX: LONGITUDINAL

CONTROLLER	CONVENTIONAL		MODE								MANEUVER ENHANCEMENT
			DRAG MOD.		VERTICAL PATH CONTROL		VERTICAL TRANSLATION		FUSELAGE AIMING		
	$\dot{\theta}$	θ	$\dot{u}$	u	$\dot{\gamma}$	γ	$\dot{w}$	w	$\dot{\theta}$	θ	
Stick Mounted Button	-	-	① -	① -	② 5	-	5	② 5	-	-	-
Vertical Force	-	-	-	-	2	-	5	5	-	-	-
Throttle Grip Mounted ③	-	-	5	-	4	-	4	4	5	5	-
Stick Control	5	5	-	-	4	-	-	-	3	3	5
Stick Mounted Thumbwheel	-	-	① -	-	4	-	4	4	4	-	-

① Throttle control more appropriate location

② Used on GCV-16, AFTI-15

③ Used on AFTI-16

APPENDIX C

TRIP REPORT

STI, NASA/DFRC, AFFTC, General/Dynamics (FW)

The first quarterly briefing was held 4 November at Systems Technology Inc. (STI). In attendance were Air Force Project Engineer, Tom Cord (AFWAL/FIGC), Roger Hoh, Wade Allen and Duane McRuer of STI, Bill Rickard of Douglas, John Hodgkinson and Kevin Citurs of MCAIR.

Following a presentation reviewing program status by Messrs. Citurs and Hodgkinson, plans for future efforts were discussed. The controller/controlled mode and mission/controlled mode matrices were reviewed and refined. These matrices will be used as a basis for contacts with other manufacturers and research organizations. The use of "pure" uncoupled responses with limiting forms as found in AFWAL-TR-81-3027 was discussed. These will be developed for all classes of aircraft with final selection to be made based on simulation time available. Tom Cord talked about the 4 axis stick on order form Measurement Systems. The use of AFTI/F-16 hardware, which will be on the LAMARS simulator concurrently with us, was pointed out as another possible set of controllers. Tom also reminded us that the use of control wheels or yokes should not be left out.

The importance of the simulation task was also emphasized. Work in this area was just beginning, but it was agreed that the task(s) must utilize both gross and fine tracking maneuvers requiring use of conventional and uncoupled control commands. The use of some of the planned AFTI/F-16 tasks in order to compare the simulator results with inflight data was also brought up. Wade Allen will be determining the software required for assessing pilot workload during simulation. Several means of measuring workload were also discussed.

On 5 November 1981 Messrs. Hoh, Hodgkinson, Cord, and Citurs traveled to Edwards Air Force Base to talk with Air Force Flight Test Center (AFFTC) and NASA Dryden Flight Research Center personnel.

The morning was spent meeting with AFFTC personnel active in the AFTI/F-16 development. In attendance were the AFTI pilots Bill Dana (NASA), Stephen Ishmael (NASA) and Maj. Harry Heimple (USAF) and AFFTC personnel Mike Frazier, Jerry Jones, Capt. Rob Crombie. After a brief on the contract status, the floor was opened to general discussion. Dana and Heimple commented on results of the AFTI ground-based simulation. They reported that gross maneuvering was accomplished using convention control. Longitudinal decoupled modes were mainly used as a vernier trimming device. Both pilots expressed enthusiam for the lateral decoupled modes, with Dana commenting how well he liked Wings Level Turn (WLT) for strafing. The general consensus was that the increased heading bandwidth of WLT was the major reason.

Following the discussion of AFTI simulation results, the topic turned to what needs to be considered by MCAIR in the performance of the contract. The AFTI simulation indicated that pilots had some difficulty deciding which controller to use, thus

increasing pilot workload. The merits of vernier versus a bang-bang control strategy for some modes should be considered. Additionally, the pilots need feedback to indicate when a decoupled mode has been saturated (e.g., authority box on HUD). Some means of displaying of feeding back aircraft states to the pilot would be useful in assisting energy management. When asked about usage of uncoupled modes in the AFTI Integrated Flight-Fire Control, Maj. Heimple indicated that the role of uncoupled modes has not been finalized yet.

The afternoon session was at NASA/DFRC with Don Berry, Terry Bezak and Mike Frazier. Mr. Berry indicated Dryden had little experience in 6 DOF controller, but would definitely be interested in the results of the current study. Several possible contacts at NASA Ames were mentioned; Al Chambers, Ed Huff, Tom Snyder and Jim Hartzell. These individuals will be contacted later. The AFTI/F-16 is scheduled to be transferred to NASA after the demonstration phase. The possibility of using the AFTI to validate the ground based simulation results at that time was discussed.

On 6 November, Messrs. Cord, Hodgkinson, and Citurs met with Jack McAllister and Chuck Anderson of General Dynamics Corp., Ft. Worth Div. Initial discussions centered around their experience with the F-16 CCV and development of the AFTI/F-16 configuration.

Dr. McAllister commented on experience with the F-16 CCV. The uncoupled motions of this aircraft could be controlled by a button mounted on top of the side stick controller (SSC). During flight tests, cross-talk between the uncoupled control and the SSC was not a problem when commanding uncoupled motions. The pilots did express a desire for some method of knowing when the control states were saturated. The maneuver enhancement modes were not thoroughly investigated due to evaluation goals and constraints.

Dr. Anderson is active on the AFTI/F-16 development program. He commented on the design philosophy used in determining controllers for the AFTI. The SSC commands normal acceleration and roll rate in all task modes except air to air, where pitch rate is the longitudinal controlled variable. The rudder pedals command all lateral uncoupled modes while the twist grip throttle controls longitudinal uncoupled motion. Forces or rates are commanded in all modes.

In the discussions that followed, several general comments were made concerning uncoupled motion control and the F-16 sidestick controller. Since changing to the limited displacement SSC from the isometric SSC, it has been possible to lower the stick force gradients. Also, it has been determined that the optimal motions for longitudinal and lateral inputs are on axes skewed and non-orthogonal as compared to the conventional axis used. The position of the pilot's hand on the SSC has been

determined to be another uncontrolled variable. Each pilot has his own technique/position, and the position chosen can have a large impact on the effective stick force gradients.

Concerning control of unconventional motion, the rudder pedals for uncoupled lateral modes were most liked by all pilots. Use of the rudder pedals to control heading appears a natural extension of the pedal function.

Discussions on singular task definition emphasized the need to include tasks which require coordination of conventional and decoupled control inputs. A task requiring gross acquisition and fine tracking maneuvers will be required to determine pilot control strategies and highlight control harmony problems.

Many important questions were raised during the trips to STI, AFFTC and NASA/DFRC. Assessment of the many comments will aid in the planning of future tasks in this effort.

APPENDIX D
PILOT EXPERIENCE

All of the pilots participating in this simulation were either active or recently active Air Force pilots. Fourteen pilots actively participated in assigning pilot ratings and giving comments of the configurations. Several others assisted in defining tasks and in checking out the simulation.

Twelve pilots from the 4950th Test Wing at Wright-Patterson AFB participated in the simulation. These were: Col. R. W. Claxton, Lt. Col. B. G. Flanary, Lt. Col. D. C. Green, Lt. Col. B. C. Tucker, Maj. A. J. Beauregard, Maj. M. D. Cary, Maj. E. J. Dorosz, Maj. C. A. Elmgren, Maj. P. A. Larkin, Maj. R. H. Lee, Jr., Captain R. P. Gradle, and Captain R. E. Sewall. All of these pilots were graduates of the USAF Test Pilot School and active in aircraft test and evaluation.

Maj. R. Luther and Captain D. G. Stephens of the AFWAL Test and Evaluation Office and Captain P. M. Weaver of the Flying Qualities Group of the AFWAL Control Dynamics Branch also served as evaluation pilots. While not Test Pilot School graduates, each of these individuals had been active Air Force pilots and were familiar with aircraft handling qualities evaluations and the Cooper-Harper rating scale.

During the simulation, each pilot was identified by a numerical code. Those pilots who took part in the air-to-air tracking evaluations were assigned an additional identification number to represent their participation in this phase. The following is a summary of pilot experience broken down by the pilot numerical code.

	Hours (approx.)
PILOT #1	
Total flying time	3840
High performance fighter/attack-jet	130
Large multi-engine-jet	3500
Variable Stability Testing	1.5
Simulation Experience	350
Significant aircraft types: F-4, A/T-37, T-38, C-130, NT-33	
PILOT #2, 23	
Total flying time	2550
High performance fighter/attack-jet	150
Large multi-engine-jet	1700
Miscellaneous	200
Simulation experience	400+
Significant aircraft types: T-37, B-52, KC-135, C-135, B-52	

	Hours (approx.)
PILOT #3	
Total flying time	3850
High performance fighter/attack-jet	1120
Forward Air Control (OV-10)	640
Large multi-engine-jet	1770
Miscellaneous	310
Variable Stability Testing	time unknown
Simulation Experience	200+
Significant aircraft types:	F/RF-4, OV-10, T-38, T-33, E-3, C-135, NT-33, B-26
PILOT #4, 21	
Total flying time	8250
High performance fighter/attack-jet	390
Large multi-engine-jet	4120
Large multi-engine-prop	2950
High performance trainer-prop	250
Helicopters	30
Miscellaneous	500
Simulation Experience	400
Significant aircraft types:	T-38, T-33, F-104, KC-97, C-135, C-130, C-141, AC-47, B-52, Sidestick controller in F-104 and C-141
PILOT #5	
Total flying time	3550
High performance fighter/attack-jet	1280
Large multi-engine-jet	2220
Large multi-engine-prop	10
Miscellaneous	50
Simulation Experience	230
Significant aircraft types:	AT-37, T-38, F-4, A-4, A-6, C-141, KC-135
PILOT #6	
Total flying time	1734
High performance fighter/attack-jet	150
Helicopters	1280
Miscellaneous	300
Simulation experience	120
Significant aircraft types:	T-38, T-37, HH-53C, UH-1

	Hours (approx.)
PILOT #7, 22	
Total flying time	2590
High performance fighter/attack-jet	830
Large multi-engine-jet	200
Large multi-engine-prop	1500
Miscellaneous	60
Simulation Experience	240
Significant aircraft types:	T-38, AT-37, C-130, C-141 experience with variable stability aircraft and side-sticks
PILOT #8	
Total flying time	5740
High performance fighter/attack-jet	280
Large multi-engine-jet	4760
Large multi-engine-prop	500
Miscellaneous	200
Simulation Experience	305
Significant aircraft types:	T-38, T-37, C-135, C-5A, C-141
PILOT #9	
Total flying time	3100
High performance fighter/attack-jet	170
Large multi-engine-jet	670
Large multi-engine-prop	1970
Miscellaneous	290
Simulation Experience	10+
Significant aircraft types:	F/RF-4, A-4, F-104, AT-37, T-38, C-130, C-135, C-141
PILOT #10	
Total flying time	2380
High performance fighter/attack-jet	160
Large multi-engine-jet	1450
Miscellaneous	780
Significant aircraft types:	T-38, A/T-37, F-4, C-135, T-39

PILOT #11

Experience unavailable, this pilot participated in checking out the approach and landing tasks. No pilot ratings were collected from this pilot.

	Hours (approx.)
PILOT #12	
Total flying time	1400
High performance fighter/attack-jet	450
Large multi-engine-jet	950
Simulation Experience	300
Significant aircraft types: T-38, C-144	
PILOT #13	
Total flying time	2180
High performance fighter/attack-jet	380
Large multi-engine-jet	1700
Miscellaneous	100
Significant aircraft types: T-38, T-37, B-52H	

PILOT #14

Detailed breakdown of experience is unavailable. The pilot had approximately 1800 hours in F-111's plus normal training. His simulation experience included several hours on the AFTI/F-16 simulation at Wright-Patterson AFB.

APPENDIX E
PILOT COMMENTS

This appendix contains the pilot comments from the simulation. During each day's evaluation, a tape recorder was kept operating, recording all of the ground-to-ground and ground-to-simulator cab conversations. The operator's discussion was kept separate from the pilot's commentary through use of the multi-channel capability of the recorder. All of the ground-to-ground conversation involving the feel system variations was kept separate from the communications lines to the pilot, and was recorded on the left channel of the tape. The pilot's discussion with the ground was recorded on the right channel.

The operator also kept a run log to record who flew what configuration when and what some of the general comments were about the configuration he was seeing. In extreme instances where pilot comments were lost due to failure in the recording process, the run log served as a back-up to give some basic idea of what the pilot saw and what his opinion was.

At the end of the simulation, the tapes were transcribed, and the transcriptions edited, and are presented in the same chronological order in which they were recorded. Editing consisted primarily of removing the ground-to-ground conversation and the ground portions of the ground-to-pilot conversations. Minor editing of the actual pilot comments also occurred, involving the placement of punctuation and the removal of words such as "uh." Spaces in between comments for a series of runs generally indicates some sort of interruption occurred, such as a ground question or the performance of another run to allow the pilot to generate a firm opinion.

Generally, the pilot comments are separated into groups by feel system configuration. Each group of comments has a header which identifies which pilot made the evaluation and what the feel system configuration being tested was, as well as any other significant describing factors. If a pilot saw a configuration three times consecutively before completing his evaluation, then those runs are grouped together under one header.

The contents of the header are intended to fully describe the particular configuration being evaluated. Immediately prior to the index to the pilot comments, is a glossary defining each of the terms and abbreviations found in the headers.

As previously mentioned, an index for the pilot comments is also presented in this appendix. This index is basically a collection of the headers from each group of runs, presented in a slightly different format, with information of where in the appendix each group of runs may be found. The three major tasks, air-to-ground weapon delivery, approach and landing and air-to-air tracking, were performed in three distinct groups with respect to

time. Runs 1 through 677 were air-to-ground, runs 678 to 981 were approach and landing and runs 2001 through 2181 and 3001 through 3195 were air-to-air tracking tasks. These divisions are also called out in the index.

Finally, the appendix also includes a list of pilot comments that were not configuration-specific but rather concerned a controller or the tasks in general. A list of these basic comments (summarized), along with the runs where they occur, follows at the end of the index to the pilot comments.

GLOSSARY

This section is an explanation of the abbreviations found in the index to the pilot comments and the pilot comment descriptive headers.

Run - the number(s) that follows is the consecutive run number.

Pilot - the pilot numbers identify the evaluation pilots and corresponds to the pilot numbers given in Appendix D, the pilot experience section.

Controller - these abbreviations identify the controller being evaluated:

.5" RP - Rudder Pedals, half inch maximum deflection.

1" RP - Rudder Pedals, one inch maximum deflection.

2" RP - Rudder Pedals, two inch maximum deflection.

3" RP - Rudder Pedals, three inch maximum deflection.

TBC - Thumb Button Controller.

TGSSC - Twist Grip Sidestick Controller.

TW - Thumbwheel Controller.

Configuration - this is generally of the form:

Breakout (or Deadband), Maneuver Gradient, Uncoupled Mode Miscellaneous.

BO - number indicates Breakout in lb.

DB - number indicates Deadband in lb or in-olb, depending on controller.

in-lb/deg, in-lb/g, lb/deg, lb/g - units for Maneuver Gradient; the number preceding this is the magnitude of the gradient.

Conventional - specifies that no uncoupled mode was tested.

AZP - Fuselage Azimuth Aiming Mode.

LTR - Lateral Translation Mode.

WLT - Wings Level Turn Mode.

APP - Approach and Landing Task.

Turbulence - number given is the rms value of the gust velocity; if not specified, not present in test.*

Xwind - gives the magnitude and direction of the crosswinds; if both directions were used, no direction is given; if not specified, not present in test.*

Motion Disturbances - disturbance input to the motion drive system independent of pilot input and turbulence; used to examine motion coupling effects.

Fixed-Base - motion drive system not operative.

*For the approach and landing task, if both the turbulence and crosswinds are not specified, 3 fps turbulence and 15 knot crosswinds were used.

Target - For the air-to-air tracking task, the comments for each controller configuration are subdivided into groups by the type of target being discussed.

Level Target - target executing moderate bank angle perturbations about a mean bank angle of zero degrees and at a constant altitude.

Fast Level Target - same as Level Target except bank angle perturbations were increased by 50% above baseline Level Target values. This was only briefly examined.

Turning Target - target executing moderate bank angle perturbations about a mean bank angle of sixty degrees and at a constant altitude.

INDEX TO PILOT COMMENTS

Air-to-Ground Weapon Delivery

Run(s)	Pilot	Controller	Configuration	Page
1-4	1	2"RP	7lb BO, 100lb/g, WLT	254
5-8	1	2"RP	7lb BO, 40lb/g, WLT	254
9-12	1	2"RP	7lb BO, 20lb/g, WLT	255
13-18	2	2"RP	7lb BO, 100lb/g, WLT	255
19-22	2	2"RP	7lb BO, 20lb/g, WLT	255
23-26	2	2"RP	7lb BO, 60lb/g, WLT	255
27	2	2"RP	7lb BO, 20lb/g, WLT	256
28-29	2	2"RP	7lb BO, 60lb/g, WLT	256
30-32	2	2"RP	7lb BO, 40lb/g, WLT	256
33-35	2	2"RP	7lb BO, 100lb/g, WLT	256
36-38	1	2"RP	4lb BO, 40lb/g, WLT	256
39-41	1	2"RP	10lb BO, 40lb/g, WLT	256
42-44	1	2"RP	20lb BO, 40lb/g, WLT	257
45-46	1	2"RP	7lb BO, 100lb/g, WLT	257
47-49	2	TGSSC	.48in-lb DB, 24in-lb/g, WLT	257
50-52	2	TGSSC	.48in-lb DB, 12in-lb/g, WLT	257
53-56	2	TGSSC	.48in-lb DB, 18in-lb/g, WLT	258
57-59	2	TGSSC	.48in-lb DB, 6in-lb/g, WLT	258
60-64	1	TGSSC	.48in-lb DB, 24in-lb/g, WLT	259
65-67	1	TGSSC	.48in-lb DB, 12in-lb/g, WLT	259
68-69	1	TGSSC	.48in-lb DB, 6in-lb/g, WLT	259
70-72	1	TGSSC	.48in-lb DB, 36in-lb/g, WLT	260
73-75	1	TGSSC	.48in-lb DB, 18in-lb/g, WLT	260
76-77	2	TGSSC	.48in-lb DB, 18in-lb/g, WLT	260
78-79	2	TGSSC	.48in-lb DB, 36in-lb/g, WLT	261

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Run(s)	Pilot	Controller	Configuration	Page
80-82	2	TGSSC	.48in-lb DB, 48in-lb/g, WLT	261
83-85	2	TGSSC	.48in-lb DB, 12in-lb/g, WLT	261
86-87	1	TGSSC	.48in-lb DB, 24in-lb/g, WLT	262
88-89	1	TGSSC	.48in-lb DB, 36in-lb/g, WLT	262
90-91	1	TGSSC	.48in-lb DB, 18in-lb/g, WLT	263
92-94	1	TGSSC	.31in-lb DB, 36in-lb/g, WLT	263
95-96	1	TGSSC	1.25in-lb DB, 36in-lb/g, WLT	263
97-98	1	TGSSC	0in-lb DB, 36in-lb/g, WLT	264
99-100	1	TGSSC	1.87in-lb DB, 36in-lb/g, WLT	264
101-103	1	TGSSC	2.50in-lb DB, 36in-lb/g, WLT	264
104-106	1	TGSSC	4.80in-lb DB, 36in-lb/g, WLT	264
107-108	2	TGSSC	.48in-lb DB, 18in-lb/g, WLT	265
109-111	2	TGSSC	.48in-lb DB, 24in-lb/g, WLT	265
112-113	2	TGSSC	.72in-lb DB, 24in-lb/g, WLT	266
114-116	2	TGSSC	2.40in-lb DB, 24in-lb/g, WLT	266
117-120	2	TGSSC	4.80in-lb DB, 24in-lb/g, WLT	266
121-125	2	TGSSC	.24in-lb DB, 24in-lb/g, WLT	267
126-128	1	TBC	.025lb DB, 5lb/g, WLT	267
129-131	1	TBC	.025lb DB, 2.5lb/g, WLT	267
132-134	1	TBC	.025lb DB, 1.667lb/g, WLT	268
135-138	1	TBC	.025lb DB, 1.25lb/g, WLT	269
139-142	3	2"RP	7lb BO, 10lb/deg, AZP	270
143	3	2"RP	7lb BO, 2lb/deg, AZP	271
144	3	2"RP	7lb BO, 6lb/deg, AZP	271
145	3	2"RP	7lb BO, 4lb/deg, AZP	271

INDEX TO PILOT COMMENTS (Continued)

Run(s)	Pilot	Controller	Configuration	Page
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149-151	4	2"RP	7lb BO, 10lb/deg, AZP	272
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157	4	2"RP	7lb BO, 2lb/deg, AZP	273
158-159	4	2"RP	7lb BO, 18lb/deg, AZP	273
160-161	4	2"RP	7lb BO, 14lb/deg, AZP	273
162-164	4	2"RP	7lb BO, 6lb/deg, AZP	273
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172-173	2	TBC	.025lb DB, 1.667lb/g, WLT	274
174-175	2	TBC	.025lb DB, 1.25lb/g, WLT	274
176-178	4	2"RP	7lb BO, 6lb/deg, AZP	274
179-180	4	2"RP	38.5lb BO, 6lb/deg, AZP	274
181-184	4	2"RP	4lb BO, 6lb/deg, AZP	275
185-188	4	2"RP	20lb BO, 6lb/deg, AZP	275
189-194	3	2"RP	7lb BO, 6lb/deg, AZP	275
195-196	3	2"RP	7lb BO, 10lb/deg, AZP	275
197	3	2"RP	7lb BO, 14lb/deg, AZP	276
198	3	2"RP	10lb BO, 10lb/deg, AZP	276
199-201	3	2"RP	10lb BO, 6lb/deg, AZP	276
202-203	3	2"RP	4lb BO, 6lb/deg, AZP	276
204-205	3	2"RP	20lb BO, 10lb/deg, AZP	276
206-207	3	2"RP	38.5lb BO, 6lb/deg, AZP	277
208-211	3	TGSSC	.48in-lb DB, 4.8in-lb/deg, AZP	277

INDEX TO PILOT COMMENTS (Continued)

Run(s)	Pilot	Controller	Configuration	Page
212-213	3	TGSSC	.48in-lb DB, 3.6in-lb/deg, AZP	278
214-217	3	TGSSC	.48in-lb DB, 2.4in-lb/deg, AZP	279
218-219	3		.48in-lb DB, 1.2in-lb/deg, AZP	280
220-221	3	TGSSC	2.40in-lb DB, 3.6in-lb/deg, AZP	281
222-227	5	2"RP	7lb BO, 6lb/deg, AZP	281
228-229	5	2"RP	7lb BO, 10lb/deg, AZP	281
230-233	5	2"RP	7lb BO, 4lb/deg, AZP	281
234	5	2"RP	7lb BO, 4lb/deg, AZP	282
235-238	5	2"RP	7lb BO, 14lb/deg, AZP	282
239-242	5	2"RP	7lb BO, 18lb/deg, AZP	283
243-245	5	TGSSC	.48in-lb DB, 4.8in-lb/deg, AZP	283
246-248	5	TGSSC	.48in-lb DB, 2.4in-lb/deg, AZP	284
249-255	5	TGSSC	.48in-lb DB, 3.6in-lb/deg, AZP	284
256-258	5	TGSSC	.48in-lb DB, 4.8in-lb/deg, AZP	285
259-262	5		.48in-lb DB, 1.2in-lb/deg, AZP	285
263-266	5	TGSSC	4.8in-lb DB, 3.6in-lb/deg, AZP	285
267-268	5	TGSSC	9.60in-lb DB, 3.6in-lb/deg, AZP	286
269-271	5	TGSSC	12in-lb DB, 3.6in-lb/deg, AZP	286

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Run(s)	Pilot	Controller	Configuration	Page
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273	6	2"RP	7lb BO, 60lb/g, WLT	287
274-276	6	2"RP	7lb BO, 20lb/g, WLT	287
277-278	6	2"RP	7lb BO, 40lb/g, WLT	287
279	6	2"RP	4lb BO, 40lb/g, WLT	288
280	6	2"RP	10lb BO, 40lb/g, WLT	288
281-282	6	2"RP	10lb BO, 40lb/g, WLT	288
283-287	7	2"RP	7lb BO, 100lb/g, WLT	288
288-291	7	2"RP	7lb BO, 40lb/g, WLT	289
292-296	7	2"RP	7lb BO, 2lb/deg, AZP	289
297-301	7	2"RP	7lb BO, 6lb/deg, AZP	289
302-303	6	TGSSC	.48in-lb DB, 24in-lb/g, WLT	289
304	6	TGSSC	.48in-lb DB, 18in-lb/g, WLT	290
305-308	6	TGSSC	.48in-lb DB, 12in-lb/g, WLT	290
309-311	6	TGSSC	.48in-lb DB, 6in-lb/g, WLT	290
312	6	TGSSC	.48in-lb DB, 48in-lb/g, WLT	290
313-314	6	TGSSC	.48in-lb DB, 36in-lb/g, WLT	291
315	6	TGSSC	.48in-lb DB, 48in-lb/g, WLT	291
316-317	6	TGSSC	.48in-lb DB, 24in-lb/g, WLT	291
318	6	TGSSC	2.40in-lb DB, 36in-lb/g, WLT	291
319	6	TGSSC	4.80in-lb DB, 36in-lb/g, WLT	292
320-321	6	TGSSC	7.20in-lb DB, 36in-lb/g, WLT	292
322-323	6	TGSSC	9.60in-lb DB, 36in-lb/g, WLT	292
324-326	6	TGSSC	14.40in-lb DB, 36in-lb/g, WLT	292

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327	6	TGSSC	.48in-lb DB, 36in-lb/g, WLT, 2 fps Turbulence	292
328	6	TGSSC	.48in-lb DB, 36in-lb/g, WLT, 4 fps Turbulence	293
329-330	6	TGSSC	.48in-lb DB, 36in-lb/g, WLT, 6 fps Turbulence	293
331	6	TGSSC	.48in-lb DB, 36in-lb/g, WLT, 8 fps Turbulence	293
332-333	6	TBC	.025lb DB, 5lb/g, WLT	293
334-335	6	TBC	.025lb DB, 2.5lb/g, WLT	294
336-337	6	TBC	.025lb DB, 1.667lb/g, WLT	294
338-340	6	TBC	.025lb DB, 1.25lb/g, WLT	294
341	6	TBC	.025lb DB, 1.0 lb/g, WLT	294
342	6	TBC	.025lb DB, .833lb/g, WLT	295
343	6	TBC	.25lb DB, 1.667lb/g, WLT	295
344-345	6	TBC	.025lb DB, 1.00lb/g, WLT	295
346-347	6	TBC	.025lb DB, 5.00lb/g, WLT	295
348-349	6	TBC	.025lb DB, 1.667lb/g, WLT	295
350-352	6	TBC	.250lb DB, 1.667lb/g, WLT	295
353-356	6	TBC	.5lb DB, 1.667lb/g, WLT	296
357-358	6	TBC	.125lb DB, 1.667lb/g, WLT	297
359-360	6	TBC	.075lb DB, 1.667lb/g, WLT	297
361-362	6	TBC	.125lb DB, 1.667lb/g, WLT	298
363	6	TBC	.025lb DB, 1.667lb/g, WLT	298
364-367	7	TGSSC	.48in-lb DB, 24in-lb/g, WLT	298
368-371	7	TGSSC	.48in-lb DB, 18in-lb/g, WLT	299

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377-382	7	TGSSC	.48in-lb DB, 6in-lb/g, WLT	299
383-385	7	TGSSC	.48in-lb DB, 48in-lb/g, WLT	299
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390	6	TBC	.025lb DB, 5lb/g, WLT	300
391-392	6	TBC	.125lb DB, 1.667lb/g, WLT	300
393	6	TBC	.250lb DB, 1.667lb/g, WLT	300
394	6	TBC	.025lb DB, 1.667lb/g, WLT	300
395	6	TBC	.025lb DB, 5lb/g, WLT	301
396	6	TBC	.025lb DB, 1.667lb/g, WLT	301
397	6	TBC	.250lb DB, 1.667lb/g, WLT	301
398-399	6	TBC	.975lb DB, 1.667lb/g, WLT	301
400-401	6	TBC	.125lb DB, 1.667lb/g, WLT	301
402	6	TBC	.5lb DB, 1.667lb/g, WLT	301
403	6	TBC	.375lb DB, 1.667lb/g, WLT	302
404-405	6	2"RP	7lb BO, 40lb/g, WLT	302
406-408	6	2"RP	7lb BO, 20lb/g, WLT	302
409-411	6	2"RP	4lb BO, 40lb/g, WLT	302
412-413	6	.5"RP	7lb BO, 40lb/g, WLT	303
414	6	.5"RP	4lb BO, 40lb/g, WLT	303
415-416	6	.5"RP	1.5lb BO, 40lb/g, WLT	303
417-419	6	.5"RP	1.5lb BO, 40lb/g, WLT	304
420-421	6	.5"RP	4lb BO, 40lb/g, WLT	304
422	6	.5"RP	1.5lb BO, 40lb/g, WLT	304
423	7	TBC	.025lb DB, 5lb/g, WLT	304

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429-431	7	TBC	.025lb DB, 1.667lb/g, WLT	305
432-433	7	TBC	.025lb DB, 1.25lb/g, WLT	306
434	7	TBC	.025lb DB, 1.667lb/g, WLT	306
435-437	7	TBC	.250lb DB, 1.667lb/g, WLT	306
438-439	7	TBC	.500lb DB, 1.667lb/g, WLT	307
440-442	7	TBC	.125lb DB, 1.667lb/g, WLT	307
443	7	TBC	.025lb DB, .833lb/g, WLT	307
444-446	7	TBC	.050lb DB, .833lb/g, WLT	307
447-454	8	2"RP	7lb BO, 60lb/g, WLT	308
455-459	8	2"RP	7lb BO, 20lb/g, WLT	308
460-461	9	2"RP	7lb BO, 6lb/deg, AZP	308
462-466	9	2"RP	7lb BO, 14lb/deg, AZP	310
467-470	9	2"RP	7lb BO, 10lb/deg, AZP	312
471-472	9	2"RP	4lb BO, 10lb/deg, AZP	313
473-474	8	2"RP	7lb BO, 20lb/g, WLT	314
475-477	8	2"RP	7lb BO, 60lb/g, WLT	315
478-485	8	2"RP	7lb BO, 40lb/g, WLT	315
486-488	9	2"RP	7lb BO, 10lb/deg, AZP	316
489-493	9	2"RP	7lb BO, 14lb/deg, AZP	316
494-497	9	2"RP	4lb BO, 10lb/deg, AZP	316
498	9	2"RP	7lb BO, 18lb/deg, AZP	317
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500-501	9	.5"RP	7lb BO, 3.5lb/deg, AZP	318
502-504	9	.5"RP	7lb BO, .5lb/deg, AZP	319

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507-508	9	.5"RP	7lb BO, 2.5lb/deg, AZP	319
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511	9	.5"RP	10lb BO, 2.5lb/deg, AZP	320
512-513	9	.5"RP	20lb BO, 2.5lb/deg, AZP	320
514-516	9	.5"RP	1.5lb BO, 2.5lb/deg, AZP	321
517-518	8	2"RP	7lb BO, 60lb/g, WLT	321
519-521	8	2"RP	7lb BO, 20lb/g, WLT	321
522-524	8	2"RP	7lb BO, 60lb/g, WLT	322
525	8	2"RP	7lb BO, 100lb/g, WLT	323
526-527	8	2"RP	7lb BO, 40lb/g, WLT	323
528-529	8	2"RP	7lb BO, 20lb/g, WLT	323
530-533	8	2"RP	7lb BO, 40lb/g, WLT	323
534-535	8	2"RP	10lb BO, 40lb/g, WLT	323
536-537	8	2"RP	20lb BO, 40lb/g, WLT	324
538	8	.5"RP	7lb BO, 25lb/g, WLT	324
539-540	9	3"RP	7lb BO, 4lb/deg, AZP	325
541-542	9	3"RP	7lb BO, 10lb/deg, AZP	325
543-544	9	3"RP	7lb BO, 6lb/deg, AZP	326
545-547	9	3"RP	7lb BO, 4lb/deg, AZP	326
548-549	9	3"RP	7lb BO, 8lb/deg, AZP	326
550-552	9	3"RP	7lb BO, 4lb/deg, AZP	327
553-555	9	3"RP	7lb BO, 2lb/deg, AZP	327
556-559	9	3"RP	1.5lb BO, 6lb/deg, AZP	328
560-561	9	3"RP	10lb BO, 6lb/deg, AZP	328

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567-568	8	.5"RP	7lb BO, 45lb/g, WLT	329
569-570	8	.5"RP	7lb BO, 35lb/g, WLT	330
571-572	8	.5"RP	7lb BO, 15lb/g, WLT	330
573-574	8	.5"RP	4lb BO, 25lb/g, WLT	330
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578	8	.5"RP	20lb BO, 25lb/g, WLT	331
579-581	10	2"RP	7lb BO, 4.0lb/deg, AZP	331
582-584	10	2"RP	7lb BO, 14lb/deg, AZP	331
585-587	10	2"RP	7lb BO, 14lb/deg, AZP	332
588-592	10	2"RP	7lb BO, 10lb/deg, AZP	332
593-595	10	.5"RP	7lb BO, 2.5lb/deg, AZP	332
596-597	10	.5"RP	7lb BO, 4.5lb/deg, AZP	332
598-600	10	.5"RP	7lb BO, 5.4lb/deg, AZP	332
601-603	10	.5"RP	7lb BO, 1.5lb/deg, AZP	332
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607	10	3"RP	7lb BO, 4lb/deg, AZP	333
608-609	10	3"RP	7lb BO, 6lb/deg, AZP	333
610-611	10	3"RP	7lb BO, 2lb/deg, AZP	333
612-614	10	3"RP	7lb BO, 4lb/deg, AZP	333
615-618	10	3"RP	7lb BO, 8lb/deg, AZP	334
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622-624	10	3"RP	7lb BO, 6lb/deg, AZP	334
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632-634	10	3"RP	7lb BO, 14lb/deg, AZP	335
635-637	10	TBC	.025lb DB, .167lb/deg, AZP	335
638-640	10	TBC	.025lb DB, .25lb/deg, AZP	335
641-644	10	TBC	.025lb DB, .5lb/deg, AZP	335
645-646	10	TBC	.025lb DB, .75lb/deg, AZP	336
647-649	10	TBC	.025lb DB, 1.00lb/deg, AZP	336
650-652	10	TGSSC	.48in-lb DB, 4.8in-lb/deg, AZP	336
653-655	10	TGSSC	.48in-lb DB, 2.4in-lb/deg, AZP	336
656-658	10	TGSSC	.48in-lb DB, 3.6in-lb/deg, AZP	336
659-660	10	TGSSC	.48in-lb DB, 1.2in-lb/deg, AZP	336
661-663	10	TGSSC	.48in-lb DB, 4.8in-lb/deg, AZP	337
664-666	10	TGSSC	.48in-lb DB, 3.6in-lb/deg, AZP	337
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673-675	10	TGSSC	2.4in-lb DB, 3.6in-lb/deg, AZP	337
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679-680	7	2"RP	Conventional, APP, 7 fps Turbulence	338
681-682	7	2"RP	Conventional, APP, 7 fps Turbulence	339
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685-690	7	2"RP	7lb BO, 100lb/g, WLT, APP 12 kt. E Xwind	340
691-694	7	2"RP	7lb BO, 100lb/g, WLT, APP, 12 kt. E Xwind	340
695-696	7	2"RP	Conventional, APP, 5 fps Turbulence	340
697	7	2"RP	Conventional, APP, 20 kt. E Xwind	340
698-699	7	2"RP	Conventional, APP, 30 kt. E Xwind	341
700	7	2"RP	Conventional, APP, 30 kt. E Xwind	341
701	7	2"RP	Conventional, APP, 30 kt. E Xwind	342
702	7	2"RP	Conventional, APP, 30 kt. W Xwind	342
703	7	2"RP	Conventional, APP, 5 fps Turbulence, 20 kt. W Xwind	342
704	7	2"RP	7lb BO, 6lb/deg, AZP, APP, 5 fps Turbulence, 20 kt. W Xwind	342

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706-708	8	2"RP	7lb BO, 6lb/deg, AZP, APP, 5 fps Turbulence, 20 kt. Xwind	343
709	8	2"RP	7lb BO, 2lb/deg, AZP, APP, 5 fps Turbulence, 20 kt. W Xwind	343
710	8	2"RP	7lb BO, 2lb/deg, AZP, APP 3 fps Turbulence, 20 kt. E Xwind	344
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741-742	12	.5"RP	7lb BO, 125lb/g, WLT, APP	347
743-744	12	.5"RP	7lb BO, 50lb/g, WLT, APP	347
745-746	12	.5"RP	7lb BO, 25lb/g, WLT, APP	347
747-748	12	.5"RP	7lb BO, 75lb/g, WLT, APP	347
749	12	.5"RP	7lb BO, 175lb/g, WLT, APP	348
750-751	12	.5"RP	7lb BO, 225lb/g, WLT, APP	348
752-753	12	.5"RP	7lb BO, 270lb/g, WLT, APP	348
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757	12	.5"RP	20lb BO, 125lb/g, WLT, APP	349
758	12	.5"RP	10lb BO, 125lb/g, WLT, APP	349
759	12	.5"RP	38.5lb BO, 125lb/g, WLT, APP	349
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790-791	14	.5"RP	7lb BO, 50lb/g, WLT, APP	353
792-793	14	.5"RP	7lb BO, 125lb/g, WLT, APP	353
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801-802	12	TGSSC	.48in-lb DB, 30in-lb/g, WLT, APP	354
803-804	12	TGSSC	.48in-lb DB, 90in-lb/g, WLT, APP	354
805-806	12	TGSSC	.48in-lb DB, 40in-lb/g, WLT, APP	354
807-808	12	TGSSC	2.40in-lb DB, 40in-lb/g, WLT, APP	355
809-810	12	TGSSC	9.6in-lb DB, 40in-lb/g, WLT, APP	355
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843-846	13	TGSSC	.48in-lb DB, 60in-lb/g, WLT, APP	359
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876-877	12	TGSSC	.48in-lb DB, 1.79in-lb/deg, LTR, APP	365
878-879	12	TGSSC	.48in-lb DB, 1.19in-lb/deg, LTR, APP	365
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882	12	TGSSC	.72in-lb DB, .72in-lb/deg, LTR, APP	366
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891-892	12	TGSSC	.72in-lb DB, 1.2in-lb/deg, AZP, APP	367
893-894	12	TGSSC	.72in-lb DB, 2.4in-lb/deg, AZP, APP	368
895	12	TGSSC	4.8in-lb DB, 1.2in-lb/deg, AZP, APP	368
896	12	TGSSC	.72in-lb DB, .8in-lb/deg, AZP, APP	368
897-898	12	TGSSC	9.6in-lb DB, .8in-lb/deg, AZP, APP	368
899-900	12	TGSSC	9.6in-lb DB, .96in-lb/deg, AZP, APP	368

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Run(s)	Pilot	Controller	Configuration	Page
901-902	14	2"RP	7lb BO, 5.97lb/deg, LTR, APP	369
903-905	14	2"RP	7lb BO, 2.98lb/deg, LTR, APP	369
906-908	14	2"RP	7lb BO, 8.95lb/deg, LTR, APP	369
909	14	.5"RP	7lb BO, 5.22lb/deg, LTR, APP	370
910-911	14	.5"RP	7lb BO, 3.73lb/deg, LTR, APP	370
912-913	14	.5"RP	7lb BO, .75lb/deg, LTR, APP	370
914-915	14	.5"RP	7lb BO, 2.24lb/deg, LTR, APP	371
916-917	14	.5"RP	7lb BO, 5.22lb/deg, LTR, APP	371
918-919	14	.5"RP	7lb BO, 8.06lb/deg, LTR, APP	372
920-921	14	.5"RP	7lb BO, 6.71lb/deg, LTR, APP	372
922-923	14	.5"RP	7lb BO, 5.22lb/deg, LTR, APP	372
924-928	Not performed			372
929-930	14	2"RP	7lb BO, 4lb/deg, LTR, APP	372
931-932	14	2"RP	7lb BO, 2lb/deg, LTR, APP	373
933-934	14	2"RP	7lb BO, 10lb/deg, AZP, APP	373
935-936	14	2"RP	7lb BO, 6lb/deg, AZP, APP	373
937-938	14	.5"RP	7lb BO, 3.5lb/deg, AZP, APP	374
939-940	14	.5"RP	7lb BO, 1.5lb/deg, AZP, APP	374
941-942	12	2"RP	7lb BO, 300lb/g, WLT, APP, Motion Disturbances	374
943	12	2"RP	7lb BO, 200lb/g, WLT, APP, Motion Disturbances	375
944	12	2"RP	7lb BO, 500lb/g, WLT, APP, Motion Disturbances	375
945	12	2"RP	7lb BO, 100lb/g, WLT, APP, Motion Disturbances	376

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Run(s)	Pilot	Controller	Configuration	Page
946	12	TGSSC	.48in-lb DB, 240in-lb/g, WLT, APP, Motion Disturbances	376
947	12	TGSSC	.48in-lb DB, 80in-lb/g, WLT, APP, Motion Disturbances	376
948	12	TGSSC	.48in-lb DB, 40in-lb/g, WLT, APP, Motion Disturbances	376
949	12	TGSSC	.48in-lb DB, 30in-lb/g, WLT, APP, Motion Disturbances	377
950	12	TGSSC	.48in-lb DB, 30in-lb/g, WLT, APP, Motion Disturbances	377
951	12	TGSSC	.48in-lb DB, 80in-lb/g, WLT, APP, Motion Disturbances	377
952	12	2"RP	7lb BO, 500lb/g, WLT, APP, Motion Disturbances	378
953	12	2"RP	7lb BO, 500lb/g, WLT, APP, Motion Disturbances	378
954	12	TW	.25lb DB (est.), 25lb/g (est.), WLT, APP, Motion Disturbances	378
955-956	12	TW	.25lb DB (est.), 12.5lb/g (est.), WLT, APP, Motion Disturbances	379
957	12	TW	.25lb DB (est.), 6.25lb/g (est.), WLT, APP, Motion Disturbances	379
958	12	TW	.25lb DB (est.), 8.33lb/g (est.), WLT, APP, Motion Disturbances	379
959	12	TW	.25lb DB (est.), 8.33lb/g (est.), WLT, APP, Motion Disturbances	379
960	12	TW	.25lb DB (est.), 8.33lb/g (est.), WLT, APP, Motion Disturbances	379

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Run(s)	Pilot	Controller	Configuration	Page
961	12	2"RP	7lb BO, 500lb/g, WLT, APP, Motion Disturbances	380
962	12	2"RP	7lb BO, 500lb/g, WLT, APP, Motion Disturbances	380
963	12	2"RP	7lb BO, 500lb/g, WLT, APP, Motion Disturbances	381
964	12	TGSSC	.48in-lb DB, 80in-lb/g, WLT, APP, Motion Disturbances	381
965	12	TGSSC	.48in-lb DB, 240in-lb/g, WLT, APP, Motion Disturbances	381
966	12	TGSSC	.48in-lb DB, 80in-lb/g, WLT, APP, Motion Disturbances	381
967	14	TW	.25lb DB (est.), 25lb/g (est.), WLT, APP, Motion Disturbances	382
968	14	TW	.25lb DB (est.), 8.33lb/g (est.), WLT, APP, Motion Disturbances	382
969	14	TW	.25lb DB (est.), 6.25lb/g (est.), WLT, APP, Motion Disturbances	382
970	14	TW	.25lb DB (est.) 8.33lb/g (est.), WLT, APP, Motion Disturbances	382
971	14	TW	Reversed Polarity, .25lb DB (est.), 8.33lb/g (est.), WLT, APP, Motion Disturbances	383
972-973	14	TW	.25lb DB (est.), 8.33lb/g (est.), WLT, APP, Motion Disturbances	384
974	14		Exact Configuration Unknown, Repeated by 976	384
975	14		Exact Configuration Unknown, Repeated by Run 977	384

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976	14	2"RP	7lb BO, 500lb/g, WLT, APP, Motion Disturbances	384
977	14	2"RP	7lb BO, 500lb/g, WLT, APP, Motion Disturbances	385
978	14	TGSSC	.48in-lb DB, 240in-lb/g, WLT, APP, Motion Disturbances	385
979	14	TGSSC	.48in-lb DB, 80in-lb/g, WLT, APP, Motion Disturbances	385
980-981	14	TGSSC	.48in-lb DB, 80in-lb/g, WLT, APP, Motion Disturbances	385
Air-to-Air Tracking				
2001-2002	21	2"RP	7lb BO, 20lb/g, WLT	386
2003-2004	21	2"RP	7lb BO, 60lb/g, WLT	386
2005-2006	21	2"RP	7lb BO, 40lb/g, WLT	387
2007-2008	21	2"RP	15lb BO, 40lb/g, WLT	388
2009-2010	21	2"RP	10lb BO, 40lb/g, WLT	388
2011-2012	21	2"RP	4lb BO, 40lb/g, WLT	389
2013-2014	22	2"RP	7lb BO, 60lb/g, WLT	390
2015-2016	22	2"RP	7lb BO, 20lb/g, WLT	390
2017	21	3"RP	7lb BO, 60lb/g, WLT	391
2018-2019	21	3"RP	7lb BO, 40lb/g, WLT	391
2020	21	3"RP	7lb BO, 40lb/g, WLT	392
2021-2023	21	3"RP	7lb BO, 60lb/g, WLT	392
2024-2026	21	3"RP	7lb BO, 20lb/g, WLT	393
2027-2028	21	3"RP	20lb BO, 60lb/g, WLT	393
2029-2031	21	3"RP	10lb BO, 60lb/g, WLT	394
2032-2034	21	3"RP	15lb BO, 60lb/g, WLT	394

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2035-2037	22	2"RP	7lb BO, 40lb/g, WLT	395
2038-2040	22	2"RP	7lb BO, 60lb/g, WLT	395
2041-2042	22	2"RP	7lb BO, 20lb/g, WLT	396
2043-2044	22	2"RP	7lb BO, 40lb/g, WLT	397
2045-2048	22	2"RP	4lb BO, 40lb/g, WLT	397
2049-2051	22	2"RP	10lb BO, 40lb/g, WLT	398
2052	22	2"RP	15lb BO, 40lb/g, WLT	398
2053	22	2"RP	20lb BO, 40lb/g, WLT	398
2054-2055	22	TGSSC	.48in-lb DB, 24in-lb/g, WLT	398
2056-2057	22	TGSSC	.48in-lb DB, 12in-lb/g, WLT	399
2058-2059	22	TGSSC	.48in-lb DB, 36in-lb/g, WLT	400
2060-2061	22	TGSSC	2.7in-lb DB, 24in-lb/g, WLT	400
2062-2063	22	TGSSC	4.8in-lb DB, 24in-lb/g, WLT	401
2064-2066	22	TGSSC	.48in-lb DB, 24in-lb/g, WLT	401
2067-2068	21	TGSSC	.48in-lb DB, 36in-lb/g, WLT	401
2069-2071	21	TGSSC	.48in-lb DB, 12in-lb/g, WLT	402
2072-2073	21	TGSSC	.48in-lb DB, 24in-lb/g, WLT	403
2074-2075	21	TGSSC	.48in-lb DB, 12in-lb/g, WLT	403
2076-2077	21	TGSSC	2.7in-lb DB, 12in-lb/g, WLT	404
2078-2079	21	TGSSC	4.8in-lb DB, 12in-lb/g, WLT	404
2080-2081	21	TGSSC	7.5in-lb DB, 12in-lb/g, WLT	405
2082-2084	22	2"RP	7lb BO, 60lb/g, WLT	405
2085-2087	22	2"RP	7lb BO, 20lb/g, WLT	406
2088-2089	22	2"RP	7lb BO, 40lb/g, WLT	407
2090-2091	22	2"RP	4lb BO, 40lb/g, WLT	407

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Run(s)	Pilot	Controller	Configuration	Page
2092-2093	22	2"RP	15lb BO, 40lb/g, WLT	407
2094-2097	22	2"RP	1.5lb BO, 40lb/g, WLT, Note: Breakout due to friction only.	407
2098-2099	22	2"RP	20lb BO, 40lb/g, WLT	408
2100-2101	22	TBC	.05lb DB, 5lb/g, WLT	408
2102-2104	22	TBC	.05lb DB, 1.25lb/g, WLT	408
2105-2106	22	TBC	.05lb DB, 2.5lb/g, WLT	409
2107-2108	22	TBC	.05lb DB, 5lb/g, WLT	410
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2116-2117	21	TBC	.05lb DB, 5lb/g, WLT	413
2118-2120	21	TBC	.05lb DB, 1.25lb/g, WLT	413
2121-2122	21	TBC	.05lb DB, 2.5lb/g, WLT	414
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2132-2133	21	1"RP	7lb BO, 40lb/g, WLT	416
2134-2135	21	1"RP	7lb BO, 20lb/g, WLT	416
2136-2137	21	1"RP	7lb BO, 60lb/g, WLT	417
2138-2139	21	1"RP	10lb BO, 20lb/g, WLT	417
2140-2141	21	1"RP	4lb BO, 20lb/g, WLT	418
2142-2143	21	1"RP	15lb BO, 20lb/g, WLT	418
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2149-2150	22	TGSSC	.48in-lb DB, 12in-lb/g, WLT Fixed-Base	419
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2154-2155	22	TGSSC	.48in-lb DB, 24in-lb/g, WLT Fixed-Base	420
2156-2157	22	TGSSC	2.7in-lb DB, 24in-lb/g, WLT Fixed-Base	420
2158-2159	22	TGSSC	4.8in-lb DB, 24in-lb/g, WLT Fixed-Base	420
2160-2162	22	TGSSC	7.2in-lb DB, 24in-lb/g, WLT Fixed-Base	421
2163-2164	22	TGSSC	.48in-lb DB, 24in-lb/g, WLT Fixed-Base	421
2165-2166	21	TGSSC	.48in-lb DB, 36in-lb/g, WLT Fixed-Base	421
2167-2168	21	TGSSC	.48in-lb DB, 12in-lb/g, WLT Fixed-Base	422
2169-2170	21	TGSSC	.48in-lb DB, 24in-lb/g, WLT Fixed-Base	423
2171-2173	21	TGSSC	2.7in-lb DB, 24in-lb/g, WLT Fixed-Base	423
2174-2176	21	TGSSC	4.8in-lb DB, 24in-lb/g, WLT Fixed-Base	424
2177-2179	21	TGSSC	7.5in-lb DB, 24in-lb/g, WLT Fixed-Base	424
2180-2181	21	TGSSC	.48in-lb DB, 24in-lb/g, WLT Fixed-Base	425
3001-3002	21	TGSSC	.48in-lb DB, 36in-lb/g, WLT	426
3003-3004	21	TGSSC	.48in-lb DB, 12in-lb/g, WLT	426

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3007-3008	21	TGSSC	2.7in-lb DB, 24in-lb/g, WLT	428
3009-3010	21	TGSSC	4.8in-lb DB, 24in-lb/g, WLT	428
3011-3012	21	TGSSC	7.5in-lb DB, 24in-lb/g, WLT	428
3013-3014	21	TGSSC	9.6in-lb DB, 24in-lb/g, WLT	428
3015-3016	21	TGSSC	.48in-lb DB, 24in-lb/g, WLT	429
3017-3021	23	TGSSC	.48in-lb DB, 36in-lb/g, WLT	429
3022-3024	23	TGSSC	.48in-lb DB, 12in-lb/g, WLT	430
3025-3026	23	TGSSC	.48in-lb DB, 24in-lb/g, WLT	430
3027-3028	23	TGSSC	2.7in-lb DB, 24in-lb/g, WLT	431
3029-3030	23	TGSSC	4.8in-lb DB, 24in-lb/g, WLT	431
3031-3032	23	TGSSC	7.5in-lb DB, 24in-lb/g, WLT	432
3033	23	TGSSC	.48in-lb DB, 24in-lb/g, WLT	432
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3036-3038	21	TBC	.05lb DB, 1.25lb/g, WLT Turbulence	433
3039-3040	21	TBC	.05lb DB, 2.5lb/g, WLT Turbulence	433
3041-3042	21	TBC	.05lb DB, 3.33lb/g, WLT Turbulence	434
3043-3044	21	TBC	.5lb DB, 3.33lb/g, WLT Turbulence	434
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3047-3048	21	TBC	1.5lb DB, 3.33lb/g, WLT Turbulence	435
3049-3050	21	TBC	.05lb DB, 3.33lb/g, WLT Turbulence	435

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3057-3058	23	TBC	.05lb DB, 1.25lb/g, WLT	437
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3062-3063	23	TBC	.05lb DB, 3.33lb/g, WLT	438
3064-3065	23	TBC	.5lb DB, 3.33lb/g, WLT	438
3066-3068	23	TBC	1.0lb DB, 3.33lb/g, WLT	439
3069-3070	23	TBC	.05lb DB, 5lb/g, WLT	439
3071-3072	23	TBC	.5lb DB, 5lb/g, WLT	439
3073	23	TBC	1.0lb DB, 5lb/g, WLT	440
3074-3075	23	TBC	1.5lb DB, 5lb/g, WLT	440
3076-3077	21	TGSSC	.48in-lb DB, 36in-lb/g, WLT Turbulence	441
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3081-3082	21	TGSSC	.48in-lb DB, 24in-lb/g, WLT Turbulence	441
3083-3085	21	TGSSC	2.7in-lb DB, 24in-lb/g, WLT Turbulence	442
3086-3087	21	TGSSC	9.6in-lb DB, 24in-lb/g, WLT Turbulence	443
3088-3089	21	TGSSC	.48in-lb DB, 24in-lb/g, WLT Turbulence	443
3090-3092	21	TGSSC	4.8in-lb DB, 24in-lb/g, WLT Turbulence	443
3093-3096	23	2"RP	7lb BO, 20lb/g, WLT	444
3097-3099	23	2"RP	7lb BO, 60lb/g, WLT	444
3100-3101	23	2"RP	7lb BO, 40lb/g, WLT	445

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Run(s)	Pilot	Controller	Configuration	Page
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3104-3106	23	2"RP	25lb BO, 40lb/g, WLT	445
3107-3109	23	2"RP	4lb BO, 40lb/g, WLT	446
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3116-3117	23	2"RP	4lb BO, 20lb/g, WLT	447
3118-3119	23	2"RP	10lb BO, 20lb/g, WLT	448
3120-3121	23	2"RP	7lb BO, 20lb/g, WLT	448
3122-3123	23	2"RP	7lb BO, 40lb/g, WLT	449
3124-3125	23	2"RP	7lb BO, 60lb/g, WLT	449
3126	23	2"RP	10lb BO, 40lb/g, WLT	450
3127	23	2"RP	4lb BO, 40lb/g, WLT	450
3128	23	2"RP	7lb BO, 40lb/g, WLT	450
3129-3130	21	2"RP	7lb BO, 20lb/g, WLT, Turbulence	451
3131-3132	21	2"RP	7lb BO, 60lb/g, WLT Turbulence	451
3133-3134	21	2"RP	7lb BO, 40lb/g, WLT Turbulence	451
3135-3136	21	2"RP	7lb BO, 20lb/g, WLT Turbulence	452
3137-3138	21	2"RP	7lb BO, 40lb/g, WLT Turbulence	452
3139-3140	21	2"RP	7lb BO, 60lb/g, WLT Turbulence	452
3141-3142	21	2"RP	15lb BO, 40lb/g, WLT Turbulence	453
3143-3144	21	2"RP	25lb BO, 40lb/g, WLT Turbulence	453

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Run(s)	Pilot	Controller	Configuration	Page
3145-3146	21	2"RP	4lb BO, 40lb/g, WLT Turbulence	453
3147-3148	21	2"RP	10lb BO, 40lb/g, WLT Turbulence	454
3149-3150	21	2"RP	20lb BO, 40lb/g, WLT, Turbulence	454
3151-3152	23	3"RP	7lb BO, 60lb/g, WLT	455
3153-3154	23	3"RP	15lb BO, 60lb/g, WLT	455
3155-3156	23	3"RP	4lb BO, 60lb/g, WLT	455
3157-3158	23	3"RP	10lb BO, 60lb/g, WLT	456
3159-3160	23	3"RP	20lb BO, 60lb/g, WLT	456
3161-3163	23	1"RP	7lb BO, 40lb/g, WLT	457
3164-3165	23	1"RP	7lb BO, 60lb/g, WLT	457
3166-3167	23	1"RP	15lb BO, 60lb/g, WLT	458
3168-3170	23	1"RP	25lb BO, 60lb/g, WLT	458
3171-3173	23	1"RP	20lb BO, 60lb/g, WLT	459
3174-3175	23	TGSSC	.48in-lb DB, 24in-lb/g, WLT, Turbulence	459
3176-3177	23	TGSSC	.48in-lb DB, 12in-lb/g, WLT, Turbulence	459
3178-3179	23	TGSSC	.48in-lb DB, 24in-lb/g, WLT, Turbulence	460
3180-3181	21	TBC	.05lb DB, 3.33lb/g, WLT, Turbulence	460
3182-3183	21	TBC	.05lb DB, 2.5lb/g, WLT, Turbulence	460
3184-3185	21	TBC	.05lb DB, 1.25lb/g, WLT, Turbulence	461
3186-3187	21	TBC	.05lb DB, 5lb/g, WLT, Turbulence	461

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Run(s)	Pilot	Controller	Configuration	Page
3188	21	TBC	.05lb DB, 3.33lb/g, WLT, Turbulence	461
3189-3191	21	TBC	.5lb DB, 3.33lb/g, WLT, Turbulence	462
3192-3193	21	TBC	1.5lb DB, 3.33lb/g, WLT, Turbulence	462
3194-3195	21	TBC	1.0lb DB, 3.33lb/g, WLT, Turbulence	462

The following is a summary of some of the more interesting comments made by the pilots during the simulation. These comments have been separated into four main categories: comments about the tasks, comments about a specific type of controller, comments comparing two or more of the controllers, and comments about the simulation. The run number where each comment can be found is given at the beginning of each of the summarized comments.

Comments About the Tasks

Run 142 Pilot 3 discusses how many corrections he is able to make in the air-to-ground task.

Run 143 Pilot 3 mentions that making more than three target adjustments is a heavy workload for the air-to-ground task.

Run 551 Pilot 9 says he is more aware of the other axes of motion when he is offset in the air-to-ground task.

Run 695 Pilot 7 finds the turbulence realistic.

Run 861 Pilot 12 wants to try setting up a crabbed approach instead of a straight approach correcting with lateral translation.

Run 2003 Pilot 21 finds the level target air-to-air tracking task too easy.

Run 2040 Pilot 22 thinks his ability to make good comments is hindered by the task of minimizing tracking error.

Run 3042 Pilot 21 feels that the turbulence level is realistic.

Comments about specific controllers

Run 141 Pilot 3 thinks that one would want to have a stiffer system air-to-ground than in an air-to-air tracking task. The controller is two inch deflection rudder pedals with fuselage azimuth aiming uncoupled mode.

Run 208 Pilot 3 suggests modifications to the twist grip shape for possible improvement.

Run 248 Pilot 5 explains what happens to his hold on the twist grip sidestick when reaching the end of the air-to-ground task. He also discusses the different grips required to use the twist as opposed to roll or pitch.

Run 288 Pilot 7 likes the wings level turn mode on the two inch deflection rudder pedals.

Run 305	Pilot 6 thinks it isn't too difficult to control pitch when using the twist grip sidestick but to control roll is difficult.
Run 310	Pilot 6 is using two different grips on the twist grip sidestick for the different phases of the air-to-ground task.
Run 332	Pilot 6 discusses how he holds the stick when operating the thumb button.
Run 335	Pilot 6 doesn't put his thumb on the thumb button until he is ready to track with it.
Run 338	Pilot 6 finds it quicker to stop the wings level turn mode if he banks into it a little bit. The controller he is using is the thumb button.
Run 428	Pilot 7 has problems making coordinated pitch and wings level turn corrections with the thumb button. As a result he tends to make discrete, single axis corrections.
Run 437	Pilot 7 thinks that he is causing inputs to the thumb button that he doesn't realize he is putting in.
Run 462	Pilot 9 describes how he holds the stick. (Note that this is a two inch deflection rudder pedal with fuselage azimuth aiming test.)
Run 501	Pilot 9 doesn't like short (.5 inch) displacement rudder pedals.
Run 538	Pilot 8 doesn't like the .5 inch displacement rudder pedals either.
Run 544	Pilot 9 says the arm movements required to roll right with a sidestick controller don't seem natural.
Run 567	Pilot 8 decides that he does like the short (.5 inch) displacement rudder pedals. The way he compensates for the short throw is to move the pedals farther out.
Run 641	Pilot 10 finds that moving the thumb button to the left causes a tendency to move the whole stick to the left.
Run 744	Pilot 12 thinks that a pilot's legs would get stiff using the .5 inch rudder pedals all of the time.
Run 813	Pilot 12 uses either the twist (commanding wings level turn) or the pitch commands but not both at once.

Run 823 Pilot 12 discusses his control strategy for using the thumb button controller.

Run 835 Pilot 12 says that he tends to ignore the vertical translation which is available to him on this run.

Run 863 Pilot 12 uses the vertical translation to increase sink rate in order to land on target in an approach and landing task.

Run 867 Pilot 12 finds that when he pulls back to flare, he also pulls up on the stifck, giving an input to the vertical translation mode.

Run 875 Pilot 12 discovers that when he grips the twist grip sidestick really hard to put in twist, he loses the sensitivity in his hand to make fine corrections.

Run 880 Pilot 12 mentions that he has so much to do just lining the aircraft up on the runway that he isn't using the vertical translation he has available.

Run 896 Pilot 12 tries to use the azimuth pointing mode with the twist grip sidestick at the same time he is putting in bank commands and he is unable to find a solution.

Run 956 Pilot 12 discusses the control strategies he is using with the thumbwheel controller with the wings level turn mode.

Run 960 Pilot 12 notices that, with the thumbwheel controller, if he moves his thumb to the other side of the wheel the sign of his inputs changes.

Run 970 Pilot 12 begins to think of the thumbwheel as a trim wheel which reverses the apparent polarity of the controller.

Run 2057 Pilot 22 finds that if he uses his hand to put so many different kinds of inputs into the stick, he sometimes releases the trigger.

Run 2069 Pilot 21 wants a fine power correction control against the level target.

Run 2070 Pilot 21 discusses the shape of the twist grip, thinking it less than optimum.

Run 2073 Pilot 21 finds that when he is displaced from the target it isn't always instinctive as to how to get back using twist.

Run 2075 Pilot 21 describes improvements he would make to the twist grip.

Run 2085 Pilot 22 finds that he didn't adjust well making the transition from a heavy maneuver gradient to a light maneuver gradient on the rudder pedals.

Run 2104 Pilot 22 says he doesn't like the feel of his thumb and trigger finger pressing against each other performing the air-to-air tracking task with the thumb button controller.

Run 2109 Pilot 22 wants to push up on the thumb button controller for pitch.

Run 2124 Pilot 21 suggests using a left hand operated trigger when using the thumb button controller.

Run 3050 The more Pilot 21 uses the thumb button, the more he likes it. He finds that pushing on the button is like moving the reticle around with his thumb.

Run 3061 Pilot 23 thinks that he initially uses the thumb button to chase the target, then he rolls in bank and gets confused.

Run 3142 Pilot 21 finds it hard to acquire the target with the rudder pedals, but once on target it is not hard to stay there.

Run 3152 Pilot 23 feels uncomfortable with the 3 inch deflection rudder pedals. He feels like he is not using it all.

Run 3161 Pilot 23 finds that the 1 inch deflection rudder pedals don't seem like enough.

Comments Comparing Controllers

Run 131 Pilot 1 says that he thinks the thumb button would have been the hardest uncoupled mode controller to begin evaluating with, as opposed to starting off with either the rudder pedals or the twist grip.

Run 242 Pilot 5 says it seems like the twist is quicker than the rudder pedals.

Run 341 Pilot 6 explains his preferences in terms of controllers; rudder pedals first, then the thumb button, and finally the twist grip sidestick.

Run 908 Pilot 14 prefers the shorter throw (.5 inch) rudder pedals to the 2 inch deflection rudder pedals when combined with the sidestick controller.

Run 954 Pilot 12 prefers the thumbwheel to the twist grip sidestick.

Run 2054 Pilot 22 says it doesn't seem to be as easy to hold a fixed twist position as it does to hold a fixed rudder pedal deflection.

Run 2072 Pilot 21 would rather track the level target with the twist grip sidestick than the rudder pedals.

Run 2100 Pilot 22 compares the thumb button, twist grip side-stick and rudder pedals for controlling uncoupled modes. He says that the thumb button operates more like the twist grip sidestick than the rudder pedals in that with the two of them he continuously makes inputs because the inputs aren't accurate enough to stay on target.

Run 2118 Pilot 21 thinks the thumb button is different from both the twist grip sidestick and the rudder pedals because with the thumb button he can only push in one direction whereas with the other two he can drive it either way.

Run 2121 Pilot 21 thinks the thumb button is easier to use than the twist grip sidestick now that he is used to it.

Run 2132 Pilot 21 likes the thumb button so much he flies with his thumb on it all of the time, even though the uncoupled mode is controlled with the rudder pedals.

Comments About The Simulation

Run 371 Pilot 7 comments on the LAMARS. He says that the initial onset of the motion is good but that he tries to correct when the motion starts to fade out.

Run 447 Pilot 8 says the motion of the simulator cab makes him feel kind of sick.

Run 960 Pilot 12 doesn't think that the motion of the simulator cab causes him to couple in inputs.

Run 2010 Pilot 21 wants another armrest on the left side of the cockpit.

Run 2012 Pilot 21 wants to be able to move the right side armrest farther outboard.

Run 2144 Pilot 21 likes the motion of the simulator cab. He says the motion makes it more of a challenge.

RUNS 1-4 Pilot 1, 2"RP, 7lb BO, 100lb/g, WLT

Okay, just for the rudder alone, I would probably say a 3 Cooper-Harper. As far as harmony with an aileron being still sensitive to the amount of force for a rudder, I'd probably put it down in a 4 range with a combined harmony: 4 or 5. That's a harmony between the rudder and aileron inputs. Pitch again, the pitch was fine. That would be I'd say around a 3 pitch and rudder, but harmony, if anything, is degraded a bit just due to the aileron sensitivity.

And rudder alone, I would probably put in the neighborhood of 3, because it was pretty good for moving -- this is small movements. I haven't put any large ones, so I'll qualify it with small heading changes. It looked good.

Rudder forces and movement seemed good.

I didn't want to put in a real hard force. Of course, I'd like to see that to give a more valid overall rating, because I would like to see what it would take with a little bit larger offset.

RUNS 5-8 Pilot 1, 2"RP, 7lb BO, 40 lb/g, WLT

Okay, I was quite a bit offset so it brought me around good, but I did overshoot. I don't know if it's my lack of technique or not, but I did - I lost time because I had to re - when I say overshoot, that's rudder only moving over to the heading. I put in a rather large correction and I did tend to overshoot although there's no oscillation involved. I went past the heading and then I came back so I was a little offset when I actually pulled the trigger. I don't know if that comes with practice or not. Moving it over to the target, it was pretty good. As far as stopping it on the target, I had a little difficulty.

First impression it was -- you know just adequate. It was enough to accomplish the task. It appeared to be. I don't know if there were any deficiencies as far as putting it down in the 4, 5, 6, range because of my overshoot. It's not clear why I did that and if it's may own input or maybe something in the system. I really couldn't tell you, so I'd say somewhere in between those two ranges.

Okay, I'd say using the rudder alone, I'd give it a 3 and it looks pretty good. As far as any fine tuning I can't say, but overall gross acquisition, getting in the ballpark, it seemed as good as any control and of course, I prefer doing that more than just straight rudder. I'd give that a 3. Again, the harmony is the same. The pitch to yaw is good, but roll to yaw (when I say yaw, what I'm talking about is wings level turn), I still don't quite like that and I think it's just in the aileron post. In other words, sidestick controller. During the whole maneuver, I had a lot of trouble with the bank, but not quite that much with

the pitch and wings level turn, so rating both, I'd say it would probably be a 4 if you're looking at harmony and a 3 rudders alone.

RUNS 9-12 Pilot 1, 2"RP, 7lb BO, 20lb/g, WLT

It seems like it takes a little bit to get it going, but it seems like I have more mechanical advantage than I had on the last two once I get the same amount of rudder force in or deflection. This one seems to turn easier to the target. For me to hold it on the target the workload's about the same, if not more.

I liked the first one. The second two seemed a little bit different as far as the forces. I like the authority, but I didn't like the forces of the last two. I'd probably give that a 4 or a 5. A good part was authority to a point, but without any feedback forces, I didn't know where I was positioning my rudders. My only indication was the nose. I couldn's lead a - my nose.

I'd probably say for that probably a 4. Does need improvement.

RUNS 13-18 Pilot 2, 2"RP, 7lb BO, 100lb/g, WLT

It was like the response was -- I was expecting an immediate.

I guess I was -- you know I stepped in on a certain amount of force and expected to see the nose pull off immediately and I guess I was kind of surprised when it didn't.

Still didn't feel like I was really controlling that time.

Like go over here. Initially I stopped him what I thought I would at least try on the rudder pedal and it seemed like there was a delay and then it I guess that's the way it's suppose to would work then. You know a delay and then it started moving and like I wasn't controlling it anymore. (No rating given)

RUNS 19-22 Pilot 2, 2" RP, 7lb BO, 20lb/g, WLT

I guess since I liked it, couldn't find a deficiency, I'd have to say it's good, negligible deficiency. 2.

RUNS 23-26 Pilot 2, 2"RP, 7lb BO, 60lb/g, WLT

I liked that. At least I - well, it took me long enough to get on, but I don't really know whether ... there was no tendency to overshoot, at least. That still - I don't know. It doesn't seem like it brings the nose over as soon - it doesn't start over as soon as you would like to. Then again, maybe I just was hesitant to stand in too much force I guess. Applied, you know, the rudder force required to do it. Fly one of those things straight and level for a second.

I don't know. It was fairly responsive. The tendency wasn't there to overshoot so ... (no rating given)

RUN 27 Pilot 2, 2"RP, 7lb BO, 20lb/g, WLT

Anyway, I just liked that. I say I did like that. (no rating given)

RUNS 28-29 Pilot 2, 2"RP, 7lb BO, 60lb/g, WLT

Okay, that was too much to try to take out with just a wings level turn, but even so, that - I don't know. That is too much force. I just that's the problem earlier when I thought it was a lag, I just wasn't settling in enough. I would say that's too much force required which would need an improvement. I don't know, I guess that's a minor but annoying deficiency. I guess I'd give it a 4.

RUNS 30-32 Pilot 2, 2"RP, 7lb BO, 40lb/g, WLT

Yeah, I like that. I would say whatever. Negligible deficiencies. That's good. Good system.

I can go with 2.

RUNS 33-35 Pilot 2, 2"RP, 7lb BO, 100lb/g, WLT

I like that. I'd give that a 2. I'd say it was good.

RUNS 36-38 Pilot 1, 2"RP, 4lb BO, 40lb/g, WLT

It would be nice if I had just a little more authority, but I would say I can accomplish the goal with it. You know, it's going to be in the neighborhood of a 3. In other words, I'm tuning up and it would probably be better.

RUNS 39-41 Pilot 1, 2"RP, 10lb BO, 40lb/g, WLT

It seems like it took a lot more force these last so many times to get it to move a little bit ahead. I mean when it moved, I could control it over to a point, but I guess switching it back and forth was a little harder, so the forces between left and right for me to compensate back and forth - I have seen better in the ones we've tried earlier.

Again, that would probably be on the lower end of the 3 scale. Maybe not quite a 4, it's tough to go between them like a 3-1/2. Give me a 3-1/2 on that one. You don't like 3-1/2 huh?

That gives us a big difference between a 3 and 4, that's why I gave you a half. I'd say it was a 3 then, but not my favorite.

RUNS 42-44 Pilot 1, 2"RP, 20lb BO, 40lb/g, WLT

I may have been using the wings level turn while I was still in a bank and just kind of slid the nose sideways down on there. I think I may have done it naturally.

The forces were really a lot higher on the rudder to a little bit of movement. I don't know if that's real bad or good to tell you the truth, because it seemed like I can hold it on the target fairly well.

The forces were up a bit higher. There was not much bobbling in the control even though the forces possibly breakout forces were much higher. It took quite a bit of force to get the heading to move. Not necessarily objectionable. Again, that would be probably around a 3 again. I can accomplish the task, but adjustment would be required. It all seemed to be doing around that range. I haven't seen something up in the 2 range and I've only seen that one seemed to be bordering on a 4.

RUNS 45-46 Pilot 1, 2"RP, 7lb BO, 100lb/g, WLT

The forces were pretty high on that hummer.

Not bad, with the forces being that high it would certainly take adjustment, because as far as moving the nose in one direction it's not bad even though the forces are very high, but if you overshoot, the build up in forces the other way the tendency is to overshoot: to go from let's say 50 pounds one way to 50 the other. They seem a bit high. I would say I can get within the ballpark. It's hard to say whether that would require warrant a lot of improvement or a minimum between a ... Yeah, it's drifting back and forth, I don't know. Again, I could do the maneuver. It comes between a 3 and a 4 again. You haven't given me anything like a 5 or a 2.

I could give it a 3.

RUNS 47-49 Pilot 2, TGSSC, .48in-lb DB, 24in-lb/g, WLT

Off hand, I'd say that whatever, good control, harmony and give it a 2 I guess.

RUNS 50-52 Pilot 2, TGSSC, .48in-lb DB, 12in-lb/g, WLT

That time I had a tendency to, when using it for the gross acquisition, I liked the response except I have a tendency to ..... it's the way I'm pushing the stick or not, but to get the bank angle in there with it. For the fine stuff, like small corrections back and forth to the target, I thought it was a little bit too sensitive on the run before, cause I had a tendency to overshoot. I had a good response I guess for making a big correction like that except for the tendency to get the bank angle in with it and I think that's my problem now.

I'd call it a 2 I guess. Maybe not, I guess the fact for the fine tracking, I guess the fact that I felt that I had a tendency to overshoot or whatever means that there's a mild unpleasant deficiency in it. I don't know. Give it a 3 for making minor corrections and probably a 2 for making the big corrections. I'm having trouble, maybe I should give it a 3. In both modes there was something about it, whether it was my problem getting the bank coupled in with it or not, I guess in both modes there were a couple of things that I really didn't care dor, then again, maybe that control harmony of getting ...

I'd say it's probably a little too sensitive and maybe a slight problem with control harmony then. The displacements and forces I didn't have any problem with that. I thought since this was the first time, I was getting a smaller displacement that might affect it since I tightened these screws up, but I don't have any problems with only that - whatever it is 3 or 4 degrees of movement of the thing. Anyway so, whatever slight problems in roll control I guess coupled in with that. I guess I'd call it a 3 overall. When I talk about control harmony, I guess cross-coupling is what I meant.

<u>RUNS 53-56</u> Pilot 2, TGSSC, .48in-lb DB, 18in-lb/g, WLT

I can't find anything wrong with that. I guess that means I have to give it good, negligible deficiencies. Still again, on the big commands and here I'm about to explain the negligible deficiencies. When I really twist the grip there's still a tendency for the bank angle to be there. Make small corrections it's easy, not easy, but it's whatever. It's not difficult to keep the bank angle out of it, but when you're making large corrections really twisting on the grip, why it's easy to get the bank angle in there. Overall, I guess I'd have to give it a 2.

<u>RUNS 57-59</u> Pilot 2, TGSSC, .48in-lb DB, 6in-lb/g, WLT

I'd give it a, well hold on. I was going to say I'd give it a 3. Still have a cross-coupling problem. I'd personally say there is a control harmony problem in this, back to the other meaning of control harmony in that. I'm getting - it is too sensitive compared to the other axis I guess.

Anyway, it's too sensitive for me at least.

It's something you can adapt to.

I guess now would I call that minor but annoying, or with moderate pilot comper ation, or objectionable with considerable? I think I'd call it minor and annoying with moderate pilot compensation. 4.

RUNS 60-64 Pilot 1, TGSSC, .48in-lb DB, 24in-lb/g, WLT

I think I can comment, my typically very general terms. For a large heading movements, it took quite a bit of compensation. It seemed a bit jerky for me to get the thing turning. Let's say I was offset 5 degrees when I tried to change the heading. The tendency was to overshoot due to the forces. I didn't quite like that, although I could get over around the target. Harmony between the pitch and the level turn wasn't bad, but between the roll and the level turn I don't think was real good. It's somewhere between a - for a large turn it was pretty near a 5 as far as a Cooper-Harper. For very small turns, in other words, not commanding much G for force, it was probably a 4. For the headings where I was very close, I'd probably give it a 4, but if you find yourself offset more than 5 degrees, it gets pretty close to a 5. It took quite a bit of compensation and I'm going to try to use all the flights yesterday as my basis so I don't change my Cooper-Harper, but the forces I can handle, they did seem a little bit high. Again, I'm comparing with the roll.

RUNS 65-67 Pilot 1, TGSSC, .48in-lb DB, 12in-lb/g, WLT

On that one, it's hard to judge to tell you the truth, because I'm somewhere between a 4 and a 5. I consider it mildly objectionable, because I kept putting in pilot induced oscillations from left to right when I attempted on purpose to sweep back and forth on the end of the runway. In other words, moving it over to a point, it wasn't real bad, but if I try to move about a point I tend to overshoot. It might be the force against the frequency of my movement, but I would tend to make a pilot induced lateral or directional oscillation, so I would say it would definitely warrant some improvement there. That was probably about a 5, higher end of the 5 scale. I should say maybe lower and closer to a 4, but it was somewhat objectionable, but I could perform the task. It just took a lot of work and I could see I was getting better at it.

RUNS 68-69 Pilot 1, TGSSC, .48in-lb DB, 6in-lb/g, WLT

I can see that after awhile I can start getting a little better at it, but it's about like the last one. The forces on there I do tend to oscillate back and forth and it would probably be about a 5. I have to admit probably the harmony with the ailerons is better, but I guess I don't like that quite as much as I thought I would as far as light forces.

Due to the light forces, I tend to overshoot and it's probably just due to the hand motion to get back to a center point move left to right, you know depending on what the breakout force is. For me to stop the movement if I overshoot and go back the other way, I tend to overshoot. So, I'm oscillating about a point and to get in close, I have to really let go and hold it there, but if I sweep back and forth, it does take quite a bit of effort. I tend to want to go back and do a fine tuning with the rudder is what I end up wanting to do when I get in close.

RUNS 70-72 Pilot 1, TGSSC, .48in-lb DB, 36in-lb/g, WLT

I guess compared to the last ones, that one wasn't bad. I like that one a bit better as far as the forces. Harmony - you know one bad thing about it and it probably comes under harmony, is I thought the forces were very high. My hand for commanding a heading to the right or right twist of my hand takes a lot of force and my hand is already getting tired for those few runs. I would give it a 4 and mainly due to the force. I did like the - as far as the control of the temper. The higher force kept me from let's say oscillating and I actually could get to the target pretty quick, but it took such a high force and again, my hands are tired from that and that is really the only objectionable part of that one.

I'd have to give it a 4 and if I had had that much control without the forces being that high and it's hard to tell with my hand's getting tired or not. I would have probably given it like a low 3 if my hand wasn't getting so tired.

If anything, to tell you the truth, it seemed like I had even better control than the first one. I seemed to have better control over it.

But again, I can see if you have to do any kind of task like this awhile, boy your hand gets tired real quick, particularly to the right. As you know, the weight turns side.

I thought again, the control wasn't bad at all. The control was almost a - I would say a 3 where it just took a little bit of compensation, but the forces definitely put it a 4.

RUNS 73-75 Pilot 1, TGSSC, .48in-lb DB, 18in-lb/g, WLT

That seemed to me a bit like one of the earlier ones. That was medium light and again, it was around a 4. It was - for some reason every time I get turning with the light ones, I induce the other axis. I'm surprised that it would do it more with the heavy ones. You know the heavy forces? I would probably say that one is a 4, because I did - I still had to work a little harder for this one than the higher forces. But then again, my hand wasn't so tired as far as a tradeoff.

RUNS 76-77 Pilot 2, TGSSC, .48in-lb DB, 18in-lb/g, WLT

I'm tempted to say good negligible deficiencies, but I still don't know whether I should let that bother me. When I first was playing with it you know before I hit the pull-up at all, you can see that the bank was still kind of coupled in with it or seemed to be. On the tracking pass itself, it worked well. I didn't really notice the bank being coupled in with it then. I don't know what you see from out there. I don't know, I'd be tempted to go with a 2 I think.

The harmony I would say was good and I mean I didn't slam myself off the side of the cockpit or whatever and there was a slight bit of cross-coupling with - you know I did have a slight problem with the roll control, but everything else I liked.

RUNS 78-79 Pilot 2, TGSSC, .48in-lb DB, 36in-lb/g, WLT

Again, this was much like the last one. When I was headed in, you know playing with it before I did the pull-up or whatever, I could feel the bank angle couple in, but in the actual run itself, I didn't notice it that much.

I don't know, I guess that's in - in the task itself, if the task is just the pop up and roll in tracking phase of it, I guess again I'd have to say that they were negligible, they didn't cause any problems or whatever. However, I still think if I were using - if I were making larger corrections with the sidestick or whatever, you know the push portion, I think I would have some problems with it. Anyway, so I guess I'd give that a 2 and say the control harmony was okay, forces displacement, all of that was okay. It's just you know the twisting at least when I was twisting quite a bit caused I guess a slight problem in roll control.

RUNS 80-82 Pilot 2, TGSSC, .48in-lb DB, 48in-lb/g, WLT

I just wanted to get a big - I have to really twist it over. I think I started to overshoot about one time there. It still wasn't that bad. I don't think that was bad at all.

I don't know what to say. I'm not sure what I'd done. On all of these you know, it's satisfactory without improvement I guess if it doesn't cause any problem in the primary task that - I mean it is satisfactory. Wouldn't know what to improve really. Again, I guess I'd have to say the deficiencies were pretty negligible or whatever here. 2.

RUNS 83-85 Pilot 2, TGSSC, .48in-lb DB, 12in-lb/g, WLT

Throwing myself around the cockpit at least, uncomfortable.

Feels kind of jerky. In fact I could easily overcontrol. I don't know, I'd say there's a tendency to overcontrol.

I don't know, it's just well sometimes you can fool yourself with, if you do change friction or breakout it makes the thing seem like they're either more sensitive or less sensitive where you're getting a different gradient when in fact you really aren't.

Well that one, I would - I don't know, from the way I was throwing myself around the - you know the jerkiness of it or my using at least, I'd say I don't know, I'd say it's got to be something or I would want some kind of improvement or whatever. I could do it again, but I guess that a minor but annoying deficiency or whatever. I don't know.

Requires improvement?

No, because we could just take intolerable power to work with by hand. Is it satisfactory without improvement? No, well I don't know let's see here. I don't know whether I'd call that mildly unpleasant or I guess, well I don't know. It didn't take a great deal of compensation I guess. It was annoying. Kind of annoying which fits into 4 but yet it didn't take a great deal of compensation for desired performance which would go into 3. I don't know.

Do you want it fixed or not and I'd say yeah for something like this. It's changing the game, yes. A 4 I guess.

<u>RUNS 86-87</u> Pilot 1, TGSSC, .48in-lb DB, 24in-lb/g, WLT

Forces were probably medium. Weren't too heavy, weren't too light. If anything, I seem to be bobbling a little bit, so again, I would probably put that around the range of a 4. I feel like I'm getting better with it, but for a large correction, I'm having a little bit of trouble with overshoots when I make a large correction, what kind of force, how far I'm moving over and stopping on the runway. So, it mildly affects me.

<u>RUNS 88-89</u> Pilot 1, TGSSC, .48in-lb DB, 36in-lb/g, WLT

I can remember this one. This is the one that I had probably one of the best control on, but the forces are high. I think that was the one - you know this was that range I was getting into where I could perform the task the best as far as the way the controller is set up, but the forces are high.

Again, the forces are really high, but when I was offset about 10 degrees and I kind of offset them purposely to see what it'd take to get over. I can get over close to the target pretty good, but again, on forces I can't do it real long. My hand starts getting tired.

Fine tracking I thought was pretty good for small movements. I'd probably say for fine tracking, if that's all I did you know like right around a runway, it's probably a 3. But, when I say the overall effect of it, moving in on a target being a little bit offset moving in it's probably a 3-1/2 or 4. A high 4, low 3. Fine tuning about a 3. But again, we'll see what happens with those other forces.

RUNS 90-91 Pilot 1, TGSSC, .48in-lb DB, 18in-lb/g, WLT

That one was about like the other one. The forces were a little bit better but then everytime the forces appear to get lighter my pitch tends to become more sensitive.

In other words, my coupling when I'm trying to change pitch a little bit.

Well, I noticed yesterday on the light one. In other words, light force type tended to get pitch sensitive. On the heavy ones I didn't and I can't figure out the relationship.

That's what happened to me yesterday. I'm doing the same thing. The forces get lighter and I like them a little bit better but I think I have trouble with the vertical pitch.

I've been working on that one. It's mildly objectionable so I would say it's a four. But I like the forces better on that one. It's just I can't control my pitch as well as I can with the one with the heavier forces. Don't know why.

RUNS 92-94 Pilot 1, TGSSC, .31in-lb DB, 36in-lb/g, WLT

As far as rating the harmony overall, I'm starting the same thing. I'm pretty busy in the pitch. The forces were high but as far as precision tracking, I didn't see anything objectionable about it. Probably just for the precision tracking task it would probably be a low 3. The thing I didn't like is the forces are still a bit high for precision tracking. But going to breakout, I didn't see anything I didn't like. In other words, I didn't bobble it or anything. You could perform a task. It's hard to say how to judge that because it might be slightly objectionable because the force is high. But for the small task, it's tolerable.

RUNS 95-96 Pilot 1, TGSSC, 1.25in-lb DB, 36in-lb/g, WLT

I don't know how much deadband is in there. That might have been inducing the oscillation but I might have just a tad more difficulty in the last one. Why don't you make this one a high 4 then. The last one was a low 3. When I say high and low, that's vertically on the Cooper-Harper scale.

It seemed to and it might---It's hard to quantify it. But to get it moving back and forth, I do some initial couple in the pitch each time I began a movement. Once I got it moving I can control that. But to get it moving, and it might be part of the geometry of my hand, I would do a pitch bobble on either end. I can't really describe why. So I seem to have just a tad more pitch sensitivities in the last one.

RUNS 97-98 Pilot 1, TGSSC, 0in-lb DB, 36in-lb/g, WLT

That one seemed a little bit easier. I'd give that a 3. Again, a little on the lower end. The forces seem---Of course, I'm living with that force anyway. But as far as the tracking task, it wasn't bad. I'd give it a 3. Low 3. I'm still coupling a little bit.

Like the last one I got a little bit more of a bobble. I don't know whether this time I have a better---It might have something to do with the size of that deadband. Can't tell.

It wasn't like I had to move my hand a lot and if I move my hand a lot and it twists, does it tend to pull back or push forward or what. I can't tell you just yet with the few runs we've had. I think if anything, I'd guess by the way my hand moves. If I twist to the right I think I pitch up and if I twist to the left I'm not sure. It might be pitching down. Of course, I've been working on the roll.

RUNS 99-100 Pilot 1, TGSSC, 1.87in-lb DB, 36in-lb/g, WLT

That one is probably in the 4 range. Probably upper 4. If anything, it looked like the response to my input was a bit more delayed than the other one. I found that, if anything, the more objectionable part to that one.

As usual, the forces are a bit high. That adds to the---It just seemed like a little more of a delay. That might be better at a lighter force. As far as maybe trying something later on. That, with a lighter force, might be better.

With a heavier force, if there's any delay at all, I can tell.

RUNS 101-103 Pilot 1, TGSSC, 2.50in-lb DB, 36 in-lb/g, WLT

But I think I'm still getting a little bit of a delay. I don't know if it's greater or less than the last one. Probably of course has something to do with the deadband, how much of a delay you have. In other words, for my input side to side is a little bit slow. I would say it's still going to be around the 4 range. Just slightly objectionable.

RUNS 104-106 Pilot 1, TGSSC, 4.80in-lb DB, 36 in-lb/g, WLT

What it was was the forces were lighter again but boy I got my pitch excited a little more than before. So I'd say it was back in the 4 range.

A little victory roll there at the end. What I did, I pulled a little early so I'd have an extra couple hundred feet. Wanted them just a little higher. I really think the side to side task isn't real bad but I seem to have just more of a pitch on those. Don't have a clue why. I'm seeing more of a pitch excitation.

It felt like this force was a little bit lighter. Maybe I'm getting stronger.

The forces were pretty high. It takes quite a bit of wrist action particularly to move the nose off to the right. That's kind of a more unnatural twist. But other that that, for the precision tracking it was about the same. I don't know about the---I might be getting just a delay but it wasn't bad. It was between a 3 and a 4.

On that, force would be a little higher. On that maneuver, bringing the nose over that much, I'd probably say it was a high 4.

I concentrated---I found myself concentrating more on the force to get it over and then to get it around the target and my concentration went away from any lead or lag. So I didn't notice that as much. So that didn't seem objectionable. My concentration was more on the force.

<u>RUNS 107-108</u> Pilot 2, TGSSC, .48in-lb DB, 18in-lb/g, WLT

It was---let's see here. I'd give them--would like to see it improved, not be so sensitive, so I guess that puts me up to 4, 5 and 6. I'd say it was minor and annoying. Although, ...

Well, it just takes not a lot of compensation, although ... I still think if a guy wanted to really get his nose on the target using it, he would probably bang his helmet off the canopy with it.

I'd say it's a minor but annoying deficiency. I don't know whether I'd say it really requires a moderate amount of pilot compensation. I suppose a 4. Back to the stuff about whether I'm really commanding a wings level turn with this thing. I keep getting bank angle no matter how I try.

Even the beginning when you are just trucking along straight and level trying to.....just playing with it.

For just minor corrections on the target, it really doesn't couple into the roll, but anything larger than a very, very minor correction it's really easy to get roll in there. As far as the amount of force or control harmony, I'm not sure about that. It still seems a little sensitive compared to the other axis....

<u>RUNS 109-111</u> Pilot 2, TGSSC, .48in-lb DB, 24in-lb/g, WLT

At first it seemed like it was too sensitive, but I kind of liked the way it came over from the target there. Maybe I'm adapting.

The comments I would make about this would be much the same as the comments before on the other one. Except during the task I really didn't have any problems.

It will slap myself off the side with it, whether that's means I'm adapting to it or not. I don't know. I still think it might be a little sensitive so I'm not sure that really needs......I don't know I guess that means there must be--what, a minimum amount of compensation required if it seems too sensitive.

I think after about one or two times of using it I think it would be okay. I guess I'm saying you would have to adapt to it, right?

It only takes one try to adapt to it. I don't know, decisions, decisions. I guess still something as easy as that, it would be so easy to do what I think would be an improvement and that is make it not quite so sensitive. I might rate this one just like the last one. Which is like a 4, the same things about control harmony, cross coupling or whatever.

RUNS 112-113 Pilot 2, TGSSC, .72in-lb DB, 24in-lb/g, WLT

I liked that. Leave that one like it is. Give that one a 2. I still---that's like...again, I'm not tracking the target but you know when we are doing the run starts and start playing with it and still get the bank angle in there. Control harmony is okay.

Well the run itself, I'd like to have brought it right over to the...moved right over to the target at least about like I expected it should.

I guess I'd give it a 2.

RUNS 114-116 Pilot 2, TGSSC, 2.40in-lb DB, 24in-lb/g, WLT

I think with that moving across sweeping it just a little bit on the target, I don't think with the deadband in either this case or the last case has been quite as easy as before.

I guess I'd give this a 2 then, I guess I kind of liked the dead-band, for the gross acquisition or whatever, and as far as the sweeping that's not quite as well, but as far as acquiring the target, I liked this, so I'd give it a 2.

RUNS 117-120 Pilot 2, TGSSC, 4.80in-lb DB, 24in-lb/g, WLT

For some reason I have a tendency to jump up and down with this. For some reason I have the tendency to elevation. When I'm twist-ing it back and forth I couple into the elevation I guess.

I guess I'd have to give that a 4. I don't really know why. I don't know what -- it's twisting it through the deadband or some-thing. I guess it must be causing it to jump up and down or maybe I'm just getting tired or something. I guess I'd have to give it a 4. That's annoying, minor. It doesn't pull way off the target. It takes moderate compensation or whatever.

<u>RUNS 121-125</u> Pilot 2, TGSSC, .24in-lb DB, 24in-lb/g, WLT

I'm still confusing myself here. There was a little bit of a pitch bobble on that thing also. I don't know if it's just me or what. I think it's satisfactory without improvement and I guess I'm going to give it a 3, mildly unpleasant. Got about very minimal pilot compensation with the ... I don't know if it's me or it pulling the nose up and down when I really wasn't trying to.

<u>RUNS 126-128</u> Pilot 1, TBC, .025lb DB, 5lb/g, WLT

I've got to look at my sheet here on a couple of things because that is really tough to do since it takes quite a bit of compensation. Because no matter what I do, particularly if I try to put my thumb in the middle, I get some of both. I will go into a roll as if I'm just rolling in on a target anyway. If I hit the side of it I can compensate better but then I have to move my thumb pretty quick to make a correction.

. . .about a 5. That's a lower 5 too. The forces seem awful high. The displacements I can't tell. I really can't tell how much my thumb moves. It's like I'm just putting a force.

I don't know if that's really desirable. It takes quite a force. It looked like the desirable thing is if you can put your thumb in the middle and move it either way to keep it from rolling and also not moving your thumb back and forth. The forces would tend to wear your thumb out. I think, giving the benefit of a doubt, a 5. So the uncoupled mode, I can't quite do an uncoupled mode if I do it like it looks like it's designed without a bit of compensation.

When I was talking about pushing on the side of the button, I was actually doing that on the outside of the button. If I do that, I can keep it from rolling a lot. But if I get a little bit off, I've got to get my thumb all the way back to the other side and move it back over to get a little bit of a heading change.

I can do away with a roll if I put my thumb in the middle but then I don't quite have the strength on it. The thumb wants to slide off. I have more trouble doing that. If I put my thumb on the side with those forces, it's like I'm getting ready to peel an apple or something. I'll put a large force on one side and I can do it. But then if I want to compensate back, I've got to get my thumb all the way back over and in that short amount of time, that's a lot of work on the old thumb. Then I start rolling. I'm doing some, I think, undesirable characteristics.

<u>RUNS 129-131</u> Pilot 1, TBC, .025lb DB, 2.5lb/g, WLT

I tend to put in more of a roll. Also, I didn't mention in the comment before, I should of, it's tough to move this and pull the trigger. Squeezing this one way and pushing the other. It's

like patting your head and rubbing your tummy. Initially I saw that right off. Everytime I pulled one I let the force off the other.

I would say this is better force-wise. But I'm doing the same things but it's not as aggravating with a lighter force. In other words, if it only takes a little -- you know, two pounds to do this one thing, three pounds to do another and then if I want to change this other one, I put in ten pounds, I'm all over the sky. I think my hand is doing an awful lot. When I pull that trigger, it's like I'm maxed out. I think if you had something for my little finger to do, I'd never catch up. If you get too many things out here you're going to have to be a pianist to do this.

Again, it's taking quite a bit of -- because of the coupling that I keep putting in, it is really tough for me to do. I think if I had done this before the other maneuvers, I would have really been way behind the power curve. In other words, before the rudder, early in the week and then the twist. This would have really been the toughest to do right off. I think this is better than the last run. But, if anything, it's probably still in a 5. You know, changes that have to be made. But I can't do the maneuver. So it still takes considerable compensation. So it's a high 5.

I can do it but I am really working hard with all my fingers. I think I'm working a lot harder right now than I have with some of the other things we've done already. My thumb is getting tired doing this.

But between the two, this one was better. I'll tell you what I find myself doing when I move my thumb and I get that roll I don't expect. I've been trying to hit the rudder to straighten the wings.

I keep taking my feet back but I want to tap the rudders and bring the wing up. So when the wing goes down and I didn't do it with the aileron, I'm putting it down and I tend to want to hit the rudder to bring the wing back up too. I do that with the T-37 and T-38.

<u>RUNS 132-134</u> Pilot 1, TBC, .025lb DB, 1.667lb/g, WLT

I tell you, just to talk about it, those forces were a little better. I could put my thumb inside and I wouldn't have to flip my thumb back and forth. Now that improved with that although it was very sensitive around the null point. But to get any movement, it wasn't bad. As far as the coupling, I'm still not good, particularly the trigger finger. In fact, I found myself getting a little apprehensive because I knew as soon as I would squeeze the trigger I would go off target and I did. You have to get the trigger and hold it so now I have a constant force to move back and forth. Just that very slight pressure on the trigger by

changing the configuration my hand the forces -- I had to rechange my position. I didn't quite like that harmony between the -- I'm not having any pitch problems. It's between the roll, the trigger -- you know, one extra function and that movement back and forth. That bit of harmony is a little complex for my hand right now. I'd still say in the 5 range although getting in on the target was better with forces. If I held the trigger, I don't know if you could see, I would be swinging like in a rocking chair back and forth over the end of the runway. As long as I kept the trigger pulled and I had to let it roll. I just had to accept that roll in there. So I'd still say it's around a 5.

It will probably go away because I've been practicing on that. But if I really want to sweep the runway and I get the high gain task I will roll.

Not grotesque but I know as soon as I pull that trigger I'm going to have to change something on my thumb in the roll and I end up changing and I find myself trying to guess what I'm going to do. It's a coordination problem maybe. Maybe it's the position of that knob.

RUNS 135-138 Pilot 1, TBC, .025lb DB, 1.25lb/g, WLT

Overshoots. Everytime I put in a force, I'd go by the target and when I'd correct it, swing back the other way and before I knew it I was going by it. I couldn't make any very fine tuning maneuvers. Maybe I was so far off that I was just overcompensating. It was a little tougher than the rest of them again to stay within the realm of the end of the runway. I don't know if you noticed, but I'd be half again the distance and over to the other side before I caught it. Just at the end, I tried to see if I could maybe put in a very slight force just for fractions of a degree movement and I couldn't.

I really had trouble on that one on every run getting the target. I could sure get in the ball park and I'm really drawn between a 6 and a 7. It was objectionable. I can kind of do the task.

It was a problem of overshoots and sensitivity. The overall movement, to a point, wasn't bad. In other words, I could put in a comfortable force and get it over. But I could not keep it on the end of the runway. In other words, everything I've seen to date, that was probably the toughest and I don't know whether how hard I was working. I'm just trying to decide whether it's a 6 or a 7. In other words, I wouldn't want that. I don't like that one at all as far as if I had to hit a point.

A little bit less and that's because it was less of a force but as far as trying to do an uncoupled flow away the end of a runway, I couldn't quite do it. I could get there if I took my finger off the button when I was close. But if I wanted to sweep

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it, it's hard to stop it and then go back. It depends on how much compensation. Maybe if I got better at it. I can give it a low 6, I guess, in earnest. I can almost give it a 7 too. So I'll leave it at a low 6.

<u>RUNS 139-142</u> Pilot 3, 2"RP, 7lb BO, 10lb/deg, AZP

That did feel pretty good and I left the pipper on the target for what I estimate to be a good solid second, second and a half. It stayed right there. Then I could rudder over to the second target and stabilize it there. It felt very good that's why I left it on there for a long time, which is unheard of. You never keep your pipper on the target very long because you are incapable of doing so. Or at least I sure was.

I assume that you probably had inputs that will tell you when you go from--that your air-to-air mode sensitivities won't probably be the same as what you would like air-to-ground. You would probably want a little stiffer system to hold the point on the ground target.

I put in quite a bit of rudder on that particular pass.

I had to put it in to get initially on target which was the left target and then I had to really cram it in to push it on over to the right target or the V/STOL runway itself.

Very comfortable task. Rolled out initially right where we wanted to which was the centerpoint which was the V/STOL taxiway, went to the left target with no problem. I had a little bit of overshoot and dropped that out real easily and stabilized, at least I thought I did, on the left target and it is very easy then going from the left target to the right target which was the center of the V/STOL taxiway or the intersection of the center taxiway in the V/STOL runway. Found it to be very comfortable. It seemed like the longer I was into the dive, the easier it was to move by rudder the firing point just with--it seemed like it was easier to do, I guess is what I'm trying to say is going from the first target to the second than it was initially on the first, if that made any sense.

I'm going to call that about a 3.

My only comment would be I still feel like I'm doing the new guy routine with the machine and that is that I'm a little too much--too rough, if you will, in pitch and dive in that particular axis. But the rudder is quite easy.

If we use the same roll in, the same run in this time I'm sure I'll be able to go for three targets, I can probably go from the center taxiway to the left to the right probably all the way back to the left. I'll just hesitate momentarily on each. I like to dampen out any kind of swing that's in the pipper. I think it is kind of unrealistic to just slop through it and then go to the other one. I don't think we are seeing much there.

It's very easy once you are going down the chute to compensate for anything and I think I probably do it unconsciously. It just feels very comfortable.

<u>RUN 143</u> Pilot 3, 2"RP, 7lb BO, 2lb/deg, AZP

I rolled out on the wrong point. Okay, I'm on the center taxiway, I'm going to rudder to the left---Oh, it is less sensitive. Back to the right, back to the left and pulled out at 500 feet which is a little low. I would say that--the system is not stiff enough. We need a little more damping in there, that's just personal opinion, very--for want of a better word--loose and causes a little bit of pendulum type overshoot.

I personally don't like that one. I don't think it would be satisfactory. I think you would throw ordnance all over the countryside if you weren't careful with that.

Let's go with deficiencies require improvement and let's go with a 7.

Probably pilot-induced pendulum overshoot.

If you initially roll down the chute on the center taxiway, making three more target adjustments after that, it's definitely a full boat.

<u>RUN 144</u> Pilot 3, 2"RP, 7lb BO, 6lb/deg, AZP

That particular time as far as the amount of force required for the pedals is better, in my opinion, certainly workable. I'd say you increased the rudder pedals forces just slightly. I would, in fact, like to see maybe just a little more. But certainly workable without change so therefore we get a little better on the Cooper-Harper scale I think we can go up into the--let me give that beauty a 5. What I'm trying to say is we improved some over the previous one.

<u>RUN 145</u> Pilot 3, 2"RP, 7lb BO, 4lb/deg, AZP

Center taxiway over to the left target, right, back left, this is a good one. That was--it wasn't as stiff as it had been for some of the other controls, however, I don't know if it was a roll in or whatever it felt like it was still a little bit light in force. I had no problem whatsoever with moving my pipper. I think a lot of that was due to the roll in that I established, which happened to hit right one. So back to the Harper Cooper thing, I'll go 4, but realize after I said that it was a fairly light stick force yet again, or a rudder force yet again.

<u>RUNS 146-148</u> Pilot 4, 2"RP, 7lb BO, 4lb/deg, AZP

You are going to have to help me with this. If we are talking about the rudders, I'd give them a 3.

Well, starting off with this one, that's the way I feel. I would be willing to go out and fly it everyday and not want it changed. You might show me something better, but right now, that's good.

Everything is fine. I don't have any--the only thing about the whole thing that bothers me is the pitch feel. But the rudder is fine. The very first time I used it it was a little bit too sensitive. But it is not.

Have problems stopping the pitch. It kind of overshoots on you. You told us to go for 3 or 4 G's, right?

Well, if I did it lighter, it wouldn't overshoot so much. It is like it is not damped when you get to the 20°. It will overshoot on you and then you have to come back, or you can let off on it sooner.

But the rudder for putting the pipper on those taxiways and run-ways show me something better. That works pretty good.

At first I didn't like it, it was a little bit too sensitive, but after several times we did it, I liked it just like it was.

<u>RUNS 149-151</u> Pilot 4, 2"RP, 7lb BO, 10lb/deg, AZP

It is going to be hard for me to differentiate between this one and the other one. I can feel the--it is less sensitive. It takes a little more force but I really believe I like the other one better but I wouldn't downgrade this one, like on your Cooper-Harper I wouldn't--it is difficult to compare the two, they are both very good.

If I said this one was as good as the other one..or if I liked the other one better I could say this was a 4 because I thought it needed improvement to get into the other one. But I really don't believe that. If I hadn't ever seen the other one, I'd say this was a 3 too.

Well I would give this one a 3 too. I would go fly this and be happy with it. Nothing else giving me problems.

<u>RUNS 152-156</u> Pilot 4, 2"RP, 7lb BO, 2lb/deg, AZP

I would take that one too, I'd give it a 3. The only thing I noticed about that one that I haven't noticed before is, I over-shot going from right to left and I don't remember doing that before. I'd still give it a 3.

It's fine. And you know I'm not working very hard to do that. I don't know why I overshot going from right to left but I did. Maybe I haven't been going from---I think I've been going from the middle to the left to the right and then back to the middle, but going from full right to full left that time, I overshot it.

RUN 157 Pilot 4, 2"RP, 7lb BO, 2lb/deg, AZP

You probably gave me the same thing, but I'll get more critical, I'll make this one a 4. The problem is and I don't know why I didn't notice it in the beginning, but it takes a little bit of work to stop it from full right to full left. It's easy to go from center to left to right, but to come back to the left again, I was either undershot or overshot. I didn't do that on the other one, so maybe it's the same thing.

RUNS 158-159 Pilot 4, 2"RP, 7lb BO, 18lb/deg, AZP

Like the 104, too hard to push.

I like to fly in my tennis shoes anyway.

I got a good feel for that one. I'd give that one a 4.

RUNS 160-161 Pilot 4, 2"RP, 7lb BO, 14lb/deg, AZP

I feel like you all are tricking me. Why do I like that one better than the one before? I would give it a 3.

No problem as far as forces or anything.

They were all good.

RUNS 162-164 Pilot 4, 2"RP, 7lb BO, 6lb/deg, AZP

Let's give that one a 3, too. The feel characteristics of that one were good.

In all of them the harmony, I thought was good.

RUNS 165-169 Pilot 2, TBC, .025lb DB, 5lb/g, WLT

Back and forth across it about three times. One time it seemed like I got a little bit of pitch coupled in with it but the rest of the time it seemed comfortable. I kind of like that.

Okay, Is it satisfactory without improvement? I think it is. Given you are going to put it in this location, right? For the sweeping back and forth across the target, Yes, I think it is. I'm not sure I would want to change anything. That slight pitch bobble, if that was really there, if that really coupled in, I guess I'd have to say, that is mildly unpleasant......

A 3.

Harmony. Just sweeping back and forth across the target, the forces are in harmony, I think for gross acquisition if I really---it still feels like to me like to get the full authority I'd have to really press on the thing, which I'm not sure I would really like. I'd say that was a harmony problem. Gross acquisition...maybe a slight problem with pitch control.

RUNS 170-171 Pilot 2, TBC, .025lb DB, 2.5lb/g, WLT

Got a little bit of pitch in there. Overall I think I would give this one just the same as the one before.

At first I thought it was a little too sensitive, but actually I think I liked it a little bit better than the one before.

I'd give it a 3 just because--there could be a tendency to couple a little bit of pitch action in with--which would be whatever....

RUNS 172-173 Pilot 2, TBC, .025lb DB, 1.667lb/g, WLT

I'm not sure if I had the pitch problem in that or not. On the first run it felt like my nose dropped a little bit, so maybe that was....Maybe that was negligible deficiencies. I might even give that a 2.

Harmony and everything seem pretty good.

RUNS 174-175 Pilot 2, TBC, .025lb DB, 1.25lb/g, WLT

I think I'd give that one a 2 also.

It is one of those things--it still doesn't seem really comfortable.

I can't really find anything wrong with it. Anyway, I didn't notice any of the pitch-bobble, or any of the nasty things that I had with the wing level turns, other times.

That seems to be a reasonable force as far as the control harmony..the other modes or whatever.

RUNS 176-178 Pilot 4, 2"RP, 7lb BO, 6lb/deg, AZP

That was really good. Maybe I'm getting used to it, but I really liked that one.

Let's rate that one. It's almost up to a 2 now. I really didn't do much of anything and it worked.

Let's just for kicks give it a 2. I don't know why I liked it, maybe I'm getting used to it.

RUNS 179-180 Pilot 4, 2"RP, 38.5lb BO, 6lb/deg, AZP

The breakout force, you had to overcome that and once I've done that I can't stop it on the target without an overshoot.

Why don't we call that one a 4. It's almost bordering on a 5.

And the reason is once I get the force in I can't stop it on the point. See, you are starting to make me very critical.

RUNS 181-184 Pilot 4, 2"RP, 4lb BO, 6lb/deg, AZP

The first time I did it I would have given it a 3, but that time I would have given it a 4.

Why don't we just leave it at that.

RUNS 185-188 Pilot 4, 2"RP, 20lb BO, 6 lb/deg, AZP

It's between a 3 and a 4. It's really pretty good but not quite as good as some of the others.

It's really no problem, that's why I'd almost go with a 3.

Let's call it a 3. It's not really annoying. It was pretty good actually. Let's say 3.

No sensitivity problems or anything of that nature.

RUNS 189-194 Pilot 3, 2"RP, 7lb BO, 6 lb/deg, AZP

It certainly is a workable system as far as force required and the rudder pedals, in my opinion it could stand to be just a little stiffer, but it certainly is acceptable. I would--just running up the magic diagram here, run it in at about the 5 level. For my personal preference we are just about there as far as the amount of force required and as far as being able to control the pipper, I feel that I am able to do that.

I think we just need a little more force to increase the rudder pedal force that--I am talking of a slight increase just on my personal preference that I'd like to see that. I feel though that I'm able to put the pipper where I want it and stop it without any oscillations after I do that, which I frankly expected to see but did not and then when I move it to a subsequent target I'm able to pull it over there and stabilize quite comfortably. It's really quite satisfactory.

RUNS 195-196 Pilot 3, 2"RP, 7lb BO, 10lb/deg, AZP

That's about what we would want to see, I don't know if you can increase the force any more. That might be the next place that I would personally like to see it go. That probably means you guys will make it less.

I didn't get a chance to stabilize this, we arrived back at the center target and took quite a bit of rudder force that time to go from the right hand target all the way across to the left-hand target. That was a significant push but I would say that's probably about the way it should be for an excursion that big.

Okay, well let me make my same comments apply and I think we are now up to scale from a 5 to a 3.

We want to go with the current condition that we are in, I'd say all the way up to a 3. We went from a 5 to a 3. In other words, we got better.

<u>RUN 197</u> Pilot 3, 2"RP, 7lb BO, 14lb/deg, AZP

Pilot comments lost. The run log indicates the pilot gave a Cooper-Harper rating of 7.

<u>RUN 198</u> Pilot 3, 2"RP, 10lb BO, 10lb/deg, AZP

Obviously, we've reduced the amount of rudder force required. I'd say that it is a little too soft, we need to come back with just a little more force required but it is something you can live with. The major deficiency here is that it had such--we reduced the rudder pedal force to such a degree that when I stabilized on a target I oscillated about it which is unacceptable, so let's--if I decided a rating right now without a repeat I'd think we are right about the 6 range. I'm sorry, make that the 7 range.

<u>RUNS 199-201</u> Pilot 3, 2"RP, 10lb BO, 6lb/deg, AZP

I can give you a rating on that one because I like it a lot.

Without going through all the positive things, I'd say a 3 or a 2. Let's just go right on up, let's go on to a 2. I've got a feeling that was the very first amount of force that you had in when we initially set the box, but I don't know. I was able to stabilize on each of the targets and apparently had the nose control I wanted with amount of push force required. It was quite comfortable and it was quite easy to control the pipper.

<u>RUNS 202-203</u> Pilot 3, 2"RP, 4lb BO, 6lb/deg, AZP

Once again I was unable to really stabilize on the point, each point of the task, I overshot after I rolled out center I was able to stabilize on that, semi-good. I went to the right target and overshot that two or three times. I went to the left target and overshot that and same is true of coming back to center. I think I'll give a lower rating to that. Slide off the scale down to 6. It's a 6.

<u>RUNS 204-205</u> Pilot 3, 2"RP, 20lb BO, 10lb/deg, AZP

We are really heavy on forces now. Especially to make a large excursion with a smaller field of traverse it would be okay, but to go out to the limits we've set for ourselves, that's significant amount of rudder force I would say just a bit more than we really want, so let's stay with a 7 on that.

What happened then is as I rolled out I moved over and tried to stabilize it and got movement left and right of my target and the same occurred when I went back through center and left target.

Let me figure out...I'd like to go with a 7 on that.

<u>RUNS 206-207</u> Pilot 3, 2"RP, 38.5lb BO, 6lb/deg, AZP

Well I'm kind of in a quandry here. I was able--there was a lot of rudder force required that time, however when I put the pipper on my target, it went right there and stabilized. I just wonder if we are getting into an area of trade-offs, if I want the slightly lighter rudder force required and if I get into the mode of once I attempt to stabilize on the target, I get the oscillations about the target which I did not get that time with the higher rudder force.

At that particular point the high rudder forces are objectionable however, the fact that you can stabilize the pipper on the target is a big plus. I'm going to go just up a notch to about the 5 level.

<u>RUNS 208-211</u> Pilot 3, TGSSC, .48in-lb DB, 4.8in-lb/deg, AZP

That was just a learning curve for me. I think I like this function, but right now when I went from the center target to the right target I overshot about twice. I really did not stabilize well on the right target at all. The physical geometry of the stick as far as accomplishing the maneuver that you want, first of all, it's a little unusual since I haven't done it before. It will take some getting used to.

If I end up having to squeeze the stick hard in order to prevent my hand from slipping on the controller, it's a little bit unnatural to perform a half-way precise movement if you are having to squeeze hard just to keep from slipping.

Let me--once again it's the geometry of the right controller, the right-hand controller---let me try to put this into words for you--I'm not able to get a good confortable grip for leverage. The actual function that it performs the movement, even though it's strange, is not that unnatural. But the geometry of the controller itself, you need some way, which I would suggest would be by possibly elongating the axis of the controller similar to what you've done with the throttle. Might help you to just get a little more leverage and perform the task.

Say for the sake of argument that, the controller, if you did a cross section on it, that it's circular. As you are sitting there with your hand around it. Instead of circular if it was more oval or football shaped with a long axis being fore and aft you would have a little more leverage and possibly be able to rotate the device a little easier.

There is center, right, and I'm off. Now that time again the movement I'm able to move to the right easier than when I want to come back to the left. When I was overstabilized on the right target and wanted to move it back I was finding myself trying to get a little more leverage from the top of the stick which has a knob that goes forward and will give me more leverage. But my hand, since it's darn near circular where your fist normally rests, you tend to slip just a little bit. As far as the amount of force required, it's about right, at least in my case, we are talking about the problem in the geometry of the controller itself.

My hand just slides around that because the bar switch mashes in. If I was going to put the bar switch there, I would put it as we look straight down at the controller over a bore in the 230.

I'll just try to grip with a stronger grip this time instead of trying to find something on the controller. Right left and off. The reason I didn't go back center that time is because I felt I was about as low as I wanted to get but by grabbing a hold harder or hanging on tighter, I'm able to do it. It just seems a little bit unnatural to do it that way because to perform the normal stick movement, you can just do it by pressing with a slight amount of force. Yet to do the left/right movement by the twist function, I gripped it damn hard but was able to do it. So once again if I'm going to assign a rating, I would give you one of that it's workable, that it's objectionable, but you can live with it so we are talking about a 6.

I guess what I'm saying is I wouldn't object to flying with it right the way it is now. By the way to do that function by twisting did not take a Paul Bunyon type death grip on the stick by any stretch of the imagination. It was just a fairly firm grip.

<u>RUNS 212-213</u> Pilot 3, TGSSC, .48in-lb DB, 3.6in-lb/deg, AZP

That was very comfortable smooth...However, I will say that time I didn't grip the stick as hard, in fact, I had my index finger pretty much in a pointing motion rather than just grip with the center two fingers and I was sliding on the controller a little bit, but it was comfortable especially compared to that other mode.

That was smooth. I'll use a different grip on the stick by the way.

I did get some slippage on the device but normally with the stick or even a sidestick you end up flying with at most your lower three fingers on your hand and your pointing finger is kind of on the trigger but it is exerting no force. Another option from that is that you just fly with the center two fingers and you're little finger is also off the stick. So there are a couple of ways. That time I was flying with just the center two and the thumb gripped around the stick and I got some slippage but I was

able to control the device, very comfortably and I went through the drill of center/left/right/back center, very smooth very comfortable.

Okay, center, left right. There's center, left, stabilize, right, that took a pretty good move, back center and off at 600 feet. I'm going to give you a pretty good one on that. I'm going to go with a 3.

By the way I am flying with feet on the floor. While we are setting up, you might have in the back of your mind about the actual stick geometry itself, as far as elongating it. I may be the only guy that has that comment though. If you are flying around with your trigger hot, it's--you really don't want to get into the mode where you have to put a good healthy grip on the stick because the next step is to put a good healthy grip on the stick when your trigger button is hot and you squeeze off rounds when you don't want to. Which I've done before, I might add.

That's called an off range release if you are in the country, in the conus and folks do get irate about that.

I think it's good that we go right first because it's when I make the large excursion in the previous case from left to right it takes a pretty good movement and that's where I get a little more of the slippage and I kind of hunt around for a little bit of a leverage point. Because I don't normally clasp my hand--grip my hand completely around the stick.

<u>RUNS 214-217</u> Pilot 3, TGSSC, .48in-lb DB, 2.4in-lb/deg, AZP

There's center, right, all the way to the left--easier--back to right, stable and off at 600. That was very comfortable, very smooth and I didn't grip my hand or anything. It was easier to do that sequence than the previous sequence although both are perfectly easy to do.

Right now it's at least a 3.

You probably saw if you were looking at the monitor that time, I had all day to do the maneuvers that I wanted to do. I was able to stabilize fairly rapidly. For some reason today I haven't been mashing that trigger button, maybe I'd better start that.

There's the center target, there's to the left, I don't know if you were watching the monitor that time on the run but I stabilized on the target and because of the way I had my hand on the stick when I went to mash the trigger I came off my target. I would like to repeat that run. That's a pretty significant point. Try a different technique this time. I've got to believe that the actual hand placement on the controller is going to be where you have in fact made a fist, in other words your thumb will be resting on your middle finger, completely around the stick with your trigger finger free and you're option is where to put it.

It has essentially been in the pointing motion, straight toward the nose of the airplane. If you are armed up hot, it is the position it is in. Rather than--get a little antsey if you let it rest on a hot trigger.

There's the center, left, all the way right, pull off.

I did not have a lot of time that time and I'm trying to mull over in my mind if the fact that I'm now mashing the trigger and I hadn't been doing that a while ago has made a difference and I think it has.

A lot of this is educational for me too because of the fact of the torquing motion.

I don't know that we need to repeat the other points, I think the fact that I'm mashing the trigger button makes the other points even that much worse. The one that required a little more strength to do.

Roll left come down, there's the center target, I'm over at the left, all the way right, and off at 500. Okay, now that wasn't too tough. I had a pretty hefty grip around the stick that time. As far as a rating goes, I'm going to stick with a 3.

Not too much problem stabilizing that time. As I was getting lower on the second point required the hand force in, in other words I was twisting right and then mashing with my trigger finger, that was a little bit of a surprise, but it is certainly workable. But it did make it a little hard for me to stabilize. I think it-really need to in the future on every run ensure that we squeeze the trigger button, not necessarily the initial roll out target but once you go left and right.

<u>RUNS 218-219</u> Pilot 3, .48in-lb DB, 1.2in-lb/deg, AZP

2000 and a roll to the right. Center target, left and oh....I didn't even squeeze off that time. I'd like to repeat it's too sensitive, in other words, it's too light a torque force and it is just like we had with the rudder pedals, what it does is when you move from the center roll-in target to the left target which we did in this case, you overshoot and oscillate like crazy. This is not going to be a good condition, but I would like to repeat it. I hope the work picture was satisfactory. The fact that you went from your initial roll-out target to the left target, you'd torque the stick around and your nose went to it and oscillated around your target to where you really never had a good pipper placement.

Pull, 22, 2000, there's center, left, see I'm oscillating, center and off at 400.

I'm going to have to drop the rating just slightly there because of the oscillations around the point. I'd like to go with a rating of 5, meaning it wasn't terribly, terribly bad, but as compared to the other condition, the one I went for my first aim point, I arrived at it and oscillated about it a little more. Then when I went from the left most target to the right most target, it was quite comfortable. I was able to stabilize but there is that little bit of oscillation there on the second half of the maneuver, the second part of this problem being the right target. The oscillation wasn't as bad as it was when I went after the left target.

RUNS 220-221 Pilot 3, TGSSC, 2.40in-lb DB, 3.6in-lb/deg, AZP

The exact pilot comments have been lost. The run log indicates that the pilot gave a Cooper-Harper rating of 4.

RUNS 222-227 Pilot 5, 2"RP, 7lb BO, 6 lb/deg, AZP

Going through this chart here, it was controllable and I thought I got adequate performance. It seems like I hit all three targets. Probably could have spent a little more time because I think I pulled out earlier than I had to. Seemed like to me the rudder forces were acceptable or I might have had a slight tendency to overshoot on the rudder. I would say probably I'd rate it a 4 just because of that. Maybe it's because I'm not used to it either. I'd say the biggest problem right now for me is just a slight tendency to overshoot and I'd have to come back on the rudder and that takes a little bit more time than it probably should.

RUNS 228-229 Pilot 5, 2"RP, 7lb BO, 10lb/deg, AZP

As the gain increased, it seemed like my tendency was to overshoot even more.

It just seemed like that configuration was a little more difficult than the first one.

That time, I guess as I got used to it, I had like one overshoot on the center target as opposed to a couple before. I think I might be just getting used to the rudder forces.

It seems like the hardest thing is coming back to that center one. I guess your gain goes up as you're getting lower in altitude and you think you're running out of time so you try a little harder.

Again I thought I had adequate performance although again it seems with the increase of gain there it did overshoot. Because of the overshooting, you had to compensate a little bit. I would say, again, a 4. I'm not sure I can directly relate that overshooting to the rudder forces either.

RUNS 230-233 Pilot 5, 2"RP, 7lb BO, 4lb/deg, AZP

I would say, just from that run compared to the others, the forces felt lighter. My tendency was to overcontrol.

Let me see if I can adjust to it.

That one looked perfect.

You know, that run felt good too. I guess maybe it's just a matter of getting used to it.

On these, I guess I need to distinguish between pilot compensation and just learning curve.

It seemed just a gut feeling that it seemed to feel better in the rudders. But, as far as performance, the last time again I seemed to have a tendency to hit the left and right target okay but then when I came back to the center, it had about one or two overshoots there that seemed to be a little annoying. I don't know if that's just because I'm trying a little harder as I'm getting close to the ground. But again I'm having to compensate for that. So again, I'd give it a 4, although it is better than the other two situations you gave me.

It was like on that configuration, I was able to move the nose a little more precisely. I still had the tendency to overshoot.

<u>RUN 234</u> Pilot 5, 2"RP, 7lb BO, 4lb/deg, AZP

The forces seemed to be a little too light. The airplane just didn't respond with the rudder movement. You kind of expect to push the rudder, move to the same direction as the rudder. When you stop applying the force, you'd expect the airplane to stop but it didn't. It just kept going.

With things happening so fast, you've got to be able to put an input and know exactly where the nose is going. If the forces are too light, it seems difficult to do.

The airplane's controllable but, much beyond that, I didn't get adequate performance. I wasn't even able to get all three targets. So I would guess, because I didn't get adequate performance, I was trying hard even to compensate and still wasn't able to do that very good, I'd have to give it a 7 because it was controllable. I don't think there was any problem with losing control of the airplane. But it certainly wasn't adequate performance.

<u>RUNS 235-238</u> Pilot 5, 2"RP, 7lb BO, 14lb/deg, AZP

First impression is that that feels better. I noticed you gave me more force there on the pedals. I was able to acquire the target a little quicker without overshooting and move from one target to the other without overshooting.

I kind of like that configuration out of all the ones I've seen. Seems like I can point the airplane with my feet and have some degree of confidence that the airplane is going to go where I put it.

I would say it had adequate performance certainly. I would say the compensation was very minor. I did have to compensate slightly though. I noticed when I pushed the rudder, say to move to the right, I had to then come back with some slightly left rudder to hold it on the target; just work it slightly. So I'd say about a 3 just because of the minor compensation. Although it could almost be a 2. Probably with a little more practice I'd give you a 2.

RUNS 239-242 Pilot 5, 2"RP, 7lb BO, 18lb/deg, AZP

I haven't said much about control harmony but it seems when you start increasing the rudder forces that you have a tendency to roll a little bit because of the light aileron forces. I still like, I think, the heavier rudder forces for acquiring the target and then not having the tendency to overshoot.

Again, I kind of like the heavier forces. It seemed like that time it took quite a bit of force to stay over there on the right target. I guess your foot would never get tired because you do it so quickly. It might be a consideration if you had to hold that force for any length of time.

I thought I had satisfactory performance. And again just minimum pilot compensation. So again I'd rate that a 3. I didn't see a whole lot of difference between that configuration and the one just prior to it as far as the forces and the ability to put the aircraft where I wanted.

If anything, I would have said it's stiffer. I guess I didn't notice the stiffness on the small corrections. But as I had to make the larger corrections, then I noticed it.

It seems like -- just comparing it with the rudders -- that they do a little quicker actually with the twist.

RUNS 243-245 Pilot 5, TGSSC, .48in-lb DB, 4.8in-lb/deg, AZP

Certainly adequate performance. Especially the last time. I was able to get on the target with a fair amount of accuracy and not much tendency to overshoot. It's easy to acquire the target and then fine tracking just didn't seem to be a big problem. However, it seemed to me like my hand, just doing this a few times, is starting to get tired already. I'd probably rate it a 4 because of that fact that you have to use a lot more force in the twist motion than you do with say a roll or pitch. It seems there might be a problem with control harmony.

RUNS 246-248 Pilot 5, TGSSC, .48in-lb DB, 2.4in-lb/deg, AZP

Performance was desirable, however, compared to the previous one, not quite as good as the other one so I tended to overshoot a little bit. It's about the same too for gross acquisition but then when I tried to track the target it tended to overshoot a little bit as the gain when up. Again, I guess I would rate that a 4 and maybe even leaning to a 5. I'd say a 4 because of having to compensate. Also, the same comment as far as the control harmony. You have to use a little more force in the twist plane than you do for the pitch or roll. It seems a little unnatural. Especially when you have to displace the aircraft from one target to the other. That requires quite a bit force to get over there. Already I can feel my hand getting tired.

One comment, I don't know if anybody else has made this, but it seems like you have to grip the stick really tight for that twist motion so your hand doesn't slip. In order to be fairly accurate on the target when you twist, you don't want your hand to be moving. So you kind of grip it real hard. Whereas, when you're flying the airplane normally, say for roll or pitch, you want to have a fairly light grip on the stick. Those two things tend to contradict each other as far as control harmony or the way you grab the stick.

Occasionally on the pull up, I tend to put a little bit of twist into it. You tend to move the aircraft where you don't want to and it's just kind of inadvertent.

Noticed though, when you use the bottom of your hand, like the bottom three fingers, for the twist and then all of the sudden you've got to pull out, so now you tend to go using the top part of your hand. So you use a lot of gyrations with your hand there on the stick.

RUNS 249-255 Pilot 5, TGSSC, .48in-lb DB, 3.6in-lb/deg, AZP

That seemed adequate performance and maybe it's just because I'm getting used to it. I don't know. But again, I thought performance was not really a problem. The only comment again I would have is the way my hand has to grab the stick and the force required to use the twist controller. If you're willing to grab the stick fairly securely during that small amount of time, it doesn't seem to be a big problem. But I'm not sure that there may be times when you have to use both the twisting motion and roll or pitch at the same time. That may be a problem with the control harmony. There seems to be a little problem in the pull up and the roll. You'll notice, when I pull up, if you put the slightest bit of twist in, then you tend to pull off to the side. You really have to concentrate on not doing that. If I diverted my attention from the screen there, when I wasn't watching the display, I really couldn't tell you whether I was putting an inadvertent input in there or not.

I guess I'd rate that again a 4 simply because of the way I have to grip the stick.

<u>RUNS 256-258</u> Pilot 5, TGSSC, .48in-lb DB, 4.8in-lb/deg, AZP

Maybe it's because I'm getting used to the controller, but I would say, again, performance is okay and may be compensating a little less. So I'm up to a 3. I'm not sure that was because the forces are less or whether I'm just getting used to it. But with the offset, it seemed like I was able to control the airplane with a little less effort. Again, however, I think with this twist controller you have to concentrate on gross acquisition a little more because of your tendency to put in twist motion. Once you've acquired the target, then the twist motion seemed to be fairly natural to make the minor changes necessary to stay on the target.

I think, if you want to summarize it, I would say it's difficult for the gross acquisition task. But once you're there, it's fairly easy and quick to maintain and to do the fine tracking and it seems fairly natural. The forces tend to get high if you have to really move to the right or left any significant distance. But I would say the biggest problem is the gross acquisition.

<u>RUNS 259-262</u> Pilot 5, .48in-lb DB, 1.2in-lb/deg, AZP

It's real tough to acquire the target. Let me try it one more time just to make sure that I can adapt to it. What makes me think that's not a good configuration is because the other ones I was able to adapt fairly quickly.

I would say that I was not able to obtain adequate performance. The first two runs, I didn't even come close to the target. So that one came a little closer but a real bad tendency to oscillate and overshoot. I would say I'd give it a 7.

<u>RUNS 263-266</u> Pilot 5, TGSSC, 4.8in-lb DB, 3.6in-lb/deg, AZP

As far as a rating there, I would say good performance, a minimum amount of compensation. So I'd go for a 3.

The inadvertent inputs in pitch and roll were better on this run. Still there is a little bit but not as bad as before. Again, though, I find the tendency is you're having to grip the stick fairly tight for the twist motion. You do couple into the roll and pitch because of the harmony aspect. The roll and the pitch is a lot lighter force than the twist.

I'm also going to try something. I'm going to try just using my fingertips on the stick instead of my whole palm. I'm not sure I'm going to be able to get enough twist action though. We'll see.

That time I tried to fly it using my fingertips like I would normally flying. If you're just flying using pitch and roll, you can grab the stick fairly lightly. You just kind of use your fingertips. But you can't really do that with a twister because it takes a little bit more force than you can generate with your fingertips. So you've got to grab the stick with the whole palm and grab it fairly tightly to accurately work the twist controller.

I did the twist with my fingertips but it seemed to be very awkward and had to use a lot of pressure on my fingers. It just didn't seem natural at all.

RUNS 267-268 Pilot 5, TGSSC, 9.60in-lb DB, 3.6in-lb/deg, AZP

As far as a rating, again, overall 3. I was able to acquire the target with minimum compensation. Again, if we go back and look at the control harmony though, I think my comment still stands in that you have to grab the stick fairly rigidly for the twist motion. It doesn't really affect you that much on the fine acquisition but you do get some inadvertent input during the gross acquisition.

Both in the roll and then when you roll out, you do get some primarily in the roll. I guess, since you know you're going to be using the twist controller, you have your hand already there in that position with the grip -- holding pretty good force on the grip. That might be part of the problem as well. I notice a lot less coupling in the pull up and in the roll especially.

RUNS 269-271 Pilot 5, TGSSC, 12 in-lb DB, 3.6in-lb/deg, AZP

I would say, as an overall comment, on the last few runs I was able to get good performance, a little easier to acquire the target previously with not as much deadband and once on the target it was fairly easy to maintain the fine tracking if you're willing to accept that fairly high grip forces on the stick. I don't think you can maintain fine tracking with just light forces on the stick like you would normally fly the airplane.

Again, overall a 3. As far as the coupling between the roll and the twist, I have less tendency to couple. But, on the other hand, if you want to roll and twist at the same time it becomes somewhat difficult because you're not sure exactly how much force to put in for the roll if you happen to be twisting at that time and you want to roll slight. Then you have a problem with control harmony and figuring out how much input to put in to give you the desired response. It's something you have to kind of think about. It doesn't come real natural. Maybe with a little practice that wouldn't be a problem.

In general, I thought the controller gave you the desired aircraft performance. You were able to put the aircraft on the target and maintain the target with a high degree of accuracy. Probably, without that control, you wouldn't be able to do those things in this particular scenario. The only comment I have is the forces are quite a bit high. It requires a fairly tight grip on the stick and then you do run into problems with control harmony, especially in roll.

<u>RUN 272</u> Pilot 6, 2"RP, 7lb BO, 100lb/g, WLT

As far as the side to side, the wings level turn, I was about half pedal deflection trying to get the turn in. I had a little bit of an overshoot when I came across the first time I was trying to stop it on the left edge of the runway and I went all the way over to the right edge. As far as maintaining it on a specific target, I'd have to say I wasn't able to stop it where I wanted it.

Again, I was trying to roll it out on the left edge of the runway, the left bottom corner of the runway. I had one overshoot coming in and brought it right back and I was having a little more trouble with pitch that time. But I finally got it squared away on the target fairly well.

Let's bump it up to a 6.

<u>RUN 273</u> Pilot 6, 2"RP, 7lb BO, 60lb/g, WLT

First target lined up fairly well. I think that was because I rolled out fairly close to it. I got the pipper over on the target with just one quick motion and stopped it. Seems like the damping on the motion is a little light and I think that's what giving me a little bit of side to side. When I tried to move it over to the left side, I had a little bit more trouble stabilizing it because I was jockeying the pedals a little bit.

I would give that a 5.

<u>RUN 274-276</u> Pilot 6, 2"RP, 7lb BO, 20lb/g, WLT

Pedal force seemed lighter. I think I overshot a little bit. I was expecting a little bit heavier forces.

Again, didn't countercommand enough on the pedals. Damping seems to be a little low. I was able to get to the second target but I never did get stabilized on it. Again, since I was unable to stabilize on it, I'd have to go with a HQR of 7.

<u>RUNS 277-278</u> Pilot 6, 2"RP, 7lb BO, 40lb/g, WLT

I seemed to have more trouble with pitch that time. I seem to have it lined up along the edge of the runway. It took me an

extra second and a half or two seconds to get the pitch stabilized on the corner. When I moved it over, it seemed like I put in almost full pedal deflection and it not only turned it but it banked the aircraft.

Got stabilized on the target real quickly when I rolled back into it. I was able to stabilize on both targets much easier. It seemed like the damping was a little higher on that one. I'd say that's moderate compensation. I'd have to give that a 4.

<u>RUN 279</u> Pilot 6, 2"RP, 4lb BO, 40lb/g, WLT

Had a, again, slight overshoot coming across to the second target. The first one I didn't seem to have much problem with. That one I had a little more problem than I did before. I'd give that a 5.

<u>RUN 280</u> Pilot 6, 2"RP, 10lb BO, 40lb/g, WLT

That seemed to be fairly easy, I had just a little bit of a bobble back and forth. The sweep was my fault. I hit the button at the wrong time. But I got stabilized on the first one within probably plus or minus 20 feet there of the edge. The sweep across to the other side was fairly easy. It seemed to stop within 20-30 feet of where I was trying to get it stopped along the edge of the runway. Because of the bobble, the overshoot, I'd have to give it a 4.

<u>RUNS 281-282</u> Pilot 6, 2"RP, 10lb BO, 40lb/g, WLT

Rolled out a little steep but it seemed I brought it right back up on target. It seemed like I had less of an overshoot than I had the last time. When I swept it across to the right target I had one overshoot, brought it right back in. I just didn't have enough time to get a good burst on it. I think that's the best one I've seen so far. I'd give that a 3.

<u>RUNS 283-287</u> Pilot 7, 2"RP, 7lb BO, 100lb/g, WLT

I rate this as satisfactory without improvement. I would not rate it at 1 because I feel it has too much lag. I would rate this a 3.

I'd say that the mildly unpleasant deficiency is excessive lag and response. I guess I would believe that I'd like to see a smaller -- and I'm not sure this is accurate because I'm not sure if I'm using more force than necessary to get full deflection which is quite likely true. To me, the forces required on the rudder pedals are significantly greater than required by the side-stick. So, in other words, I think there's a lack of harmony between the two in this configuration. Sensitivity, in my mind, means able to achieve a given rate and I would like to see a greater rate.

I'd like to see the mode a little quicker basically; the build up and yaw rate.

And the control authority, in my mind, that's the maximum rate which I can achieve. I would not object to seeing the rate peak at a higher rate at a higher level. In other words, more authority.

RUNS 288-291 Pilot 7, 2"RP, 7lb BO, 40lb/g, WLT

If at all, that is complementary to the mode. I like the mode. I'd like so much to see more of it or something.

I think I need to come in here and, having said all those things last time about more sensitivity, I now feel like I have too much sensitivity. I feel like I'm moved back closer to the basic aircraft where the yaw motion is almost undamped. The response is so good that I am overshooting because of the rate buildup, I suppose. I would rate this one as a 4.

A couple of these comments could be interesting contradictions. However, this time I feel like force is not a problem. There's not a disharmony between the rudder pedals and the sidestick controller. I feel like I'm getting the amount of displacement I need with the proper amount of force. I do feel like I've got more sensitivity than I can really handle here. I really can't say too much about the authority at this point because I haven't done a point where I've been significantly off where I could actually compare -- In my mind, when I say "authority" I'm thinking of a steady state rate.

RUNS 292-296 Pilot 7, 2"RP, 7lb BO, 2lb/deg, AZP

Exact comments lost. Notes from the run log indicate that the pilot had problems with overshoots and attributed the problem to a need for more damping. Cooper-Harper 4.

RUNS 297-301 Pilot 7, 2"RP, 7lb BO, 6lb/deg, AZP

Exact comments lost. Notes from the run log show that the pilot felt that the control harmony and forces were good. Cooper-Harper 3.

RUNS 302-303 Pilot 6, TGSSC, .48in-lb DB, 24in-lb/g, WLT

I have a tendency to overcontrol on that. I have an overshoot coming back through. In fact, I actually came through too far. I was trying to stop on the opposite side of the runway and came all the way through it. So, since I was already lined up on the second target, I went for that and then came back. But sensitivity seemed to be a little bit too much on the overshoot. Let me see if I can rate this. We'll go with the 6. As far as getting it trained on the target, it went through about two overshoots before I could get it down. It just seemed like the time span that it took, I was almost all the way down at the bottom before I really got set on the other target for shooting.

RUN 304 Pilot 6, TGSSC, .48in-lb, 18in-lb/g, WLT

Seemed like it was fairly light forces. Not enough damping. Still overshooting. I can control it okay. I can move it back and forth but I can't stop it where I want it exactly. That was a little bit better than the last one. I'd give that a 5.

RUNS 305-308 Pilot 6, TGSSC, .48in-lb DB, 12in-lb/g, WLT

It's not too difficult to control pitch when you're trying to twist this thing, but to control the bank is a little touchy.

I'm having a little bit of trouble right there but I can hold it within about two bar widths on the bars on the end of the runway. I think that's about 40 feet. I was able to get it on there apparently because I rolled out pretty much on the first target. It only required small corrections. Once I got it stable on the first target, it was pretty easy to drag it over to the second one and I noticed just a little bit of bobbling there, probably left and right, about 40 feet. I give that an HQR of 5.

RUNS 309-311 Pilot 6, TGSSC, .48in-lb DB, 6in-lb/g, WLT

Much better. Much easier to use. I was able to get stabilized on the targets much better that way. Smaller tendency to over-control that I have had in the previous runs. Having to use just small like maybe two per second movements to try to keep it within that -- What I've set up is to try to maintain it within a ±20 foot spread of the corner of the runway and using about two per second small inputs to do that. I'd go with an HQR of 4 on that.

What I've had to change was if I fly the airplane while I'm fully gripping the stick, what I find is that when I start to twist the grip, I've got it already off centered one way or the other and that's what's giving me -- I'm ending up feeding bank into it and that's complicating the problem. So what I'm doing is I'll fly the thing with as light a touch as I can just using my fingers until I get rolled out, wings level going down there. From that position, then I can go ahead and grab the stick and I know that the stick is in a fairly centered position so I'm not introducing that much roll into it. But in order to twist it, you've still got to grab the thing.

I will have to say, comparing this against using the rudder pedals yesterday, I prefer the rudder pedals.

RUN 312 Pilot 6, TGSSC, .48in-lb DB, 48 in-lb/g, WLT

I like that a lot better. Much better control and I was able to move the target over. What I did is I tried to slow down my rate of acquiring the second target; slow down the lateral acceleration. I was able to control that a lot better. I stopped it. Rolled it out right where I wanted to. That went a lot easier.

I'm using less authority. I find out if you're trying to be too aggressive with it, all you do is you end up overcontrolling. The gain on the task is too high. So what I had to do is just slow down a little bit and that seems to work a lot better. From what we just did there, I'd have to give that an HQR of 3.

That looked like more of the way it was supposed to work. It's just bang on the first target and then right over to the second one without a lot of overshoots and bobbling around.

RUNS 313-314 Pilot 6, TGSSC, .48in-lb DB, 36in-lb/g, WLT

That seemed to work a little bit better. Just a real small input to overshoot that time on the second one but I think it was probably within one bar width on the end of the runway. I think the biggest problem was just that I was still trying to roll the airplane. But once I can get over that, I think that'll work pretty good. I'd have to give that a 3.

RUN 315 Pilot 6, TGSSC, .48in-lb DB, 48in-lb/g, WLT

Went a little bit below where I wanted to that time. I seemed to come across all right but it was a little slow coming across. I was having to put in more force than I reckoned I would have to. It seemed like the force gradient was a little high. Let me get you a rating.

Because of the fact I was having trouble getting in the second target, I'd have to give that a 5.

RUNS 316-317 Pilot 6, TGSSC, .48in-lb DB, 24in-lb/g, WLT

Seemed like I was again having difficulty getting it to settle down on the target. It was overshooting. I would command it and when I tried to stop it, it would not stop as quickly as I wanted it to. I was able to get it on the target but it took quite a bit of effort. I'll rate it. It's a 5.

RUN 318 Pilot 6, TGSSC, 2.40in-lb DB, 36in-lb/g, WLT

I didn't notice too much about the deadband. It seemed like it was reacting fairly quickly. Didn't have too much trouble getting on either of the targets. The second one I got off more because I banked the airplane more than anything else. But it was fairly easy to get both targets. I have to give that just a 4 because of the little bit of trouble I was having bobbling on the second target. Seemed like I was having to come back and forth. I used about three or four small corrections trying to get it centered on the second target and I was having to move from side to side a little bit.

RUN 319 Pilot 6, TGSSC, 4.80in-lb DB, 36in-lb/g, WLT

The bobble again was due to it. I can roll it to the right. If I want to make the aircraft turn the right, I can do that fairly well without putting in too much bank. But when I try to roll it back to turn the aircraft back to the left I'm inducing bank into it. I didn't have very much trouble at all holding it on either target at that time. I'd have to give that one a 3. Does this thing have a different force gradient going one way than it does the other?

I didn't think so. Sometimes that makes a difference. I noticed like down here on your twist for your throttle here you've got two different springs and sometimes they'll change the force gradients on one side or the other.

RUNS 320-321 Pilot 6, TGSSC, 7.20in-lb DB, 36in-lb/g, WLT

I'm still not noticing any appreciable amount of deadband in there. It seems to move as soon as I tell it to move. That one was probably about the best run so far. I had both targets by the time I was passing through 1,300 feet.

Again, as long as you don't try to overcontrol it to make it move too quickly it seems to steady out quite a bit. That one I only made about two or three control motions in that whole thing. I'd have to give that a 2. That was about the easiest one so far to control.

RUNS 322-323 Pilot 6, TGSSC, 9.60in-lb DB, 36 in-lb/g, WLT

Just a light hint of a bobble going onto the right target. Induced a little bank again. Any time I do that that throws the whole solution off because as soon as it banks a little bit, when I twist it, not only does it yaw but it drags the pipper down below the target. It's like you're inducing a pitch motion into it. But that's the same problem with inducing the bank into it.

I would go with a 3.

RUNS 324-326 Pilot 6, TGSSC, 14.40in-lb DB, 36in-lb/g, WLT

Seems like I'm having to use a lot of twist motion to get it to move. I can still notice the amount of deadband in it. It was possible to keep it on the target with a lot of effort. I was using fairly large twist forces trying to keep it centered on the target. As far as an HQR, I'd say that was considerable effort and that was a 5.

RUN 327 Pilot 6, TGSSC, .48in-lb DB, 36in-lb/g, WLT, 2 fps Turbulence

Exact comments lost. Notes from the run log indicate that the pilot felt the turbulence was realistic but he was experiencing wing rock. Cooper-Harper 4.

RUN 328 Pilot 6, TGSSC, .48in-lb DB, 36in-lb/g, WLT, 4 fps Turbulence

Exact comments lost. The run log notes show that the pilot commented on pitch oscillations and gave a Cooper-Harper rating of 4.

RUNS 329-330 Pilot 6, TGSSC, .48in-lb DB, 36in-lb/g, WLT, 6 fps Turbulence

A little bit higher turbulence that time. I was having a little bit more trouble in both pitch and yaw and keeping the target fixed. Didn't have any problems with the controller. I think most of the stuff was just the turbulence. But I was able to keep it on the target within say 40 or 50 feet of the intended target.

I didn't see any major problems on that. Seemed to be keeping within say 50 feet of the target both times. Even with the turbulence it's moderate compensation. I'd give that a 4.

RUN 331 Pilot 6, TGSSC, .48in-lb DB, 36in-lb/g, WLT, 8 fps Turbulence

With the higher turbulence I wasn't able to keep it on target within about 50 feet or so. I just kind of swept through it rather than really fixing the target.

That's probably typical of what you would encounter on an actual mission. Especially for this altitude. (No rating given)

RUNS 332-333 Pilot 6, TBC, .025 lb DB, 5lb/g, WLT

That's much easier to use than with the twist in the controller.

I'm holding the stick very loosely. Most of the control motions I'm making are just push/pull type motions rather than gripping the stick and trying to move it.

As far as the button goes, I'm pushing more on the edges of it than on the center of it.

I'm just rolling my thumb back and forth across the top.

Getting off a short burst but I'm not having any trouble getting or keeping the pipper on the target. That seems fairly easy to do. The only compensation I'm really having to do is there's a tendency, when I roll in command with a thumb input, that there is a force. It's almost like you're trying to roll the aircraft. You're pushing the whole controller to the side. So there's some small amount of tendency to couple the aircraft in roll when you do that and that just takes a little bit of -- You have to sort of stiffen up on the control when you do that. But it's much simpler tnan trying to twist the whole thing around. I would give that an HQR of 3. It is a little bit unnatural. You have to concentrate on doing it because I tend to think of this type

of a command motion in terms of yaw so I'm trying to use the pedals a little bit. You have to concentrate on using the button.

RUNS 334-335 Pilot 6, TBC, .025lb DB, 2.5lb/g, WLT

I'm not having any trouble. It seems like the responses are fairly heavily damped. It'll start over and as soon as I let up on the button it stops just where I want it. There's no oscillation back and forth at all. Again, I'm just having a slight amount of coupling. It seems like whenever I've got my thumb on it or move one direction or the other with the thumb, I'm moving the controller because the airplane's trying to roll on me. With that, again I'd give it a 3. I think with the lighter force, that tendency would probably diminish.

I just put my thumb on the button when I get ready to track with it.

RUNS 336-337 Pilot 6, TBC, .025lb DB, 1.667lb/g, WLT

I'm not having any trouble with that at all. The forces seemed a little bit lighter than they were before and I'm not even tending to put in the bank like I was before. I'd call that negligible deficiencies. I'd give that a 2.

RUNS 338-340 Pilot 6, TBC, .025lb DB, 1.25lb/g, WLT

Sometimes it's easier if I go in one direction it stops a little quicker if I bank into it a little bit. I started off kind of in a slight right bank and came level when I was on the center target and a little bit of a left bank when I was on the right hand target. That's probably not a good technique to use with this but it seems to stop the pipper on the target a little quicker.

I felt like it was a little stiffer than it did before.

I think what's different is it seems like the damping is not as heavy as it was. I got two overshoots trying to acquire the first target. When I came to the second target what I did is I just stopped the command prior to when I wanted it to stop and it just kind of eased over and stopped where I wanted it to. It was just a real quick learning curve getting to figure out where it was going to stop. I'd say that's pretty mild. Mildly unpleasant deficiencies. I'd give that a 3.

RUN 341 Pilot 6, TBC, .025lb DB, 1.0lb/g, WLT

As far as comparing it to the twist grip, this is much easier to use because you've still got direct control over the roll authority while you're doing your wings level turn. In other words, a natural control. When I get the airplane banking I can still move the controller side to side while I'm playing with my

thumb which is much more difficult to do when you have to try to twist the whole controller around. I like this better than the twist thing but I still tend to prefer the pedals.

And again, a little bit of an overshoot when I was going to pick up the two targets. I went past the first target once and had to come back to it. When I came back to the second target the same thing happened. I overshot it to the outside so I had to go back to it. I'd give that a 4.

RUN 342 Pilot 6, TBC, .025lb DB, .833lb/g, WLT

It doesn't seem to have the overshoot problems that time. Was able to get it stopped within a tolerable distance from where I was aiming: within 20 feet or so. It was an improvement over the last one. Go with a 3 on that.

RUN 343 Pilot 6, TBC, .25lb DB, 1.667lb/g, WLT

Comments lost.

RUNS 344-345 Pilot 6, TBC, .025lb DB, 1.00lb/g, WLT

As far as the control went, without any turbulence or anything as soon as I got stabilized on the first target it just stayed there. Bringing it back across to the second target I overshot once and cranked it right back with just one small, it was just an in-out motion of the controller and after that it stayed on the target good. Because of the one overshoot I'd go with a 4.

RUNS 346-347 Pilot 6, TBC, .025lb DB, 5.00lb/g, WLT

I'd go with a rating of 3. I think I just used more command input that time and brought the pipper right over to the target without any problem.

The additional amount of input didn't seem to cause me any problems or anything like that.

I had a -- after I put the input in, I ended up with a slight amount of bank into it which I think is from feeding it in like I was doing, but it didn't hurt the firing solution any.

RUNS 348-349 Pilot 6, TBC, .025lb DB, 1.667lb/g, WLT

Seems like the damping is a little bit less than it was on the previous one. I overshot and had to come back to it that time.

It's seems fairly simple once you get it stable, either that or throw some turbulence in there. Once I rolled out on target it wasn't any problem. I'd have to give that a 2.

RUNS 350-352 Pilot 6, TBC, .250lb DB, 1.667lb/g, WLT

I didn't notice any problem as far as the deadband goes. I can tell that the damping is a little bit less than we've been working with before because I'm having to stop my motion when it's yea far from the target and I can watch it from the time I stop

and just kind of drifts over a little bit and settles down so there is a minor amount of damping there. Lighter damping than we've been using. The deadband, I didn't notice any problem with that.

There seems to be just a very slight hesitation on the deadband, enough that I had to try and kind of give it a little more command than I was anticipating in order to get it started moving.

It seemed like there -- I seem to notice just a slight hesitation in getting it to start moving when I put the command in and consequently to get it to stop moving when I took the command out. I'll go with a rating of 4.

What do I mean by damping? Well, when I get the controller moving -- when I get the airplane in a wings level turn and I release the button, there is a certain period of time between when you release the button and when the aircraft actually stops turning. When I release the button I am expecting the airplane to settle down to a straight-ahead flight to stop the wings level turn and there seems to be a lag when I let go of the controller to when the airplane actually stops and I interpret that as a lower damping coefficient. At higher damping coefficients it will stop immediately and as you decrease the damping coefficients the time constant increases so it takes a longer time for the thing to stop.

<u>RUNS 353-356</u> Pilot 6, TBC, .5lb DB, 1.667lb/g, WLT

It seems a little bit slow on the response, I can't quite put my finger on it, but it just seems like it's slower than it was before. Consequently when I put in what I thought was the normal amount of command, bring it to the second target, it stops short of the second target so I had to use the second command to get it over to where I wanted it.

Overshot the target twice there. Overshot that one again also. Tried to roll out, offset and that brings the target over and I overshot it and had to come back to it and I did that going to the second target also.

I can't quite figure out what is preventing me from getting it on the target the first time.

It doesn't seem like offset is any problem because I'm rolling out still fairly close to the target. I'm just having trouble getting it over and on it. I can't quite figure out why.

Still fairly close to the target right now. I bring it over and it doesn't stop right on the target. That one worked out a little bit better than the ones before. It seems like there is a lag from the time I tell the thing to stop moving until it actually settles down. That's what it appears from here.

I haven't been using reverse commands to stop it on a point. I've just been bringing it over and then just prior to where I actually want it to stop I just remove the command and it will naturally -- it continues a little bit past that and then it stops.

If you are not changing the damping or any of the dynamics the time constant should be the same, the only things that should change is how long it takes based on how fast I have the thing coming over and I know I have to have been using pretty close to your maximum turn rate here on most of these.

It seems to be getting worse for some reason. I'd have to go with a 5 on that.

<u>RUNS 357-358</u> Pilot 6, TBC, .125lb DB, 1.667lb/g, WLT

First target I had an overshoot coming across from left to right and I overshot to the right and had to bring it back. Second target it came over pretty well and when it came back to the middle, that worked fairly well. It seemed a little bit better other than that one overshoot at the beginning.

It just had a real slight bobble on at the bottom on the first one. It took me two commands, left commands to get it over to the targets. I purposely rolled out to where I was pointing to the right of the target and had to come back left and get to it. It took me -- it stopped short of where I was going that time. That wasn't bad, minor problems, I'd give that a 4.

I've been using the controller more as an on/off, bang-bang type controller than anything else. When you get down in to moving it just from one side of the runway to the other where you are only talking about -- I assume these are 300 foot wide runways here. If you are just going between two sides of the runways you don't need the full command authority the controller has. I don't think I've been using full command authority, but to get it onto the target initially, it's just full deflection until it's about maybe 100 feet away and then I cut the controller and let it drift over there and settle down on the target.

<u>RUNS 359-360</u> Pilot 6, TBC, .075lb DB, 1.667lb/g, WLT

Controller seemed a little slow to react that time. It felt like I had to put in about a quarter to a fifth of what I was putting in before just to get it to start moving. It seemed a little sloppy to try to make fine corrections. With that second target we drifted off to the side and it took me a little bit to get it back because I was putting in corrections waiting for it to come back for a small correction. It took it a while just to start moving.

Again, it seems like I've got a little bit of a deadband hesitation in trying to move the controller side to side. I'd go back down to a 5 on that.

And the basic problem was I think I got a hesitation.

RUNS 361-362 Pilot 6, TBC, .125lb DB, 1.667lb/g, WLT

It seems like on that run I was drifting to the right. Both of the first two targets, when I got stabilized on them, all of a sudden I was drifting to the right. The second one, rather than using the controller it was easier just to roll in a couple degrees of bank opposite to that and then hold it with the bank. Both of them it seemed like I was drifting off to the right when I got set up.

I think the problem may be it seems I've still got a deadband in here. When it starts going one way and I release the controls, I'm having to go all the way opposite, starting a counter motion to get it to stop. If that makes sense. It seems like I'm having to make a lot more control inputs just to hold it onto the target. I'd call that considerable effort. We'll give that a 5.

RUN 363 Pilot 6, TBC, .025lb DB, 1.667lb/g, WLT

That was not much better than it was before. It seemed again like I was drifting back and forth and I was using quite a bit of thumb motion just trying to get the thing to stay on target. I'd go with a 5 on that too. I was just using a lot of side to side couple motion just to keep the thing on target.

RUNS 364-367 Pilot 7, TGSSC, .48in-lb DB, 24in-lb/g, WLT

I'm sitting in here wondering and I'm going to go it a 4.

I don't have a problem with the forces. Displacement: I might be happier with a smaller displacement with the thought that if I used smaller displacement it might -- I'm not sure if this is even accurate. But it might prevent me from coupling into pitch and roll. I'm not sure. Sensitivity: I kind of tie that in with displacement. I think I would like to see less wrist movement because the same amount of authority available with less wrist movement just because twisting your wrist is a little bit unnatural. The actual control itself, I felt that I'm cross controlling a little bit; putting inputs into other axes. That's obviously undesirable. It seems to me though that it's more noticeable in pitch than roll and I recall having, with the rudder controller last time, a little problem with pitch. It's conceivable that it's really not the fault of the sidestick.

It may be the fault of the sidestick but it's not the fault of the twist grip I guess is what I'm really saying. And maybe that I just have problems with the basic airplane.

No turbulence. Piloting technique you tend to think about trying to put a pure input in so that when you twist the grip you don't change the pitch attitude. I went with the 4 instead of -- I was lost in between 3 and 4 because I think there's no problem with control or anything like that. It's a deficiency because I feel more comfortable with the rudder pedal.

I feel that if I wanted to correct this deficiency, I might do something with it besides the twist grip.

RUNS 368-371 Pilot 7, TGSSC, .48in-lb DB, 18in-lb/g, WLT

I like it better. 3.

I don't feel like I'm having to put as much wrist action into getting the desired and I don't know if that's small displacement or sensitivity or what.

I see less problem with the pitch this time. I feel good about the authority. I could feel the side forces in the seat. The LAMARS is really good for the input but the fade out sometimes creates a little problem. I react to the fade out. Let's say I'm pitching up and then it starts to fade out the motion. I sense that and I attempt to correct that. It doesn't bear on this present experiment.

RUNS 372-376 Pilot 7, TGSSC, .48in-lb DB, 12in-lb/g, WLT

Back to a 4.

And the reason is because I think the forces are too high to get the proper amount of displacement. I guess whenever I say the forces are too high, I'm also thinking a comment about harmony. Well, I guess maybe that's not true. I was thinking harmony because I'm saying relative to what I have to put in for pitch and roll inputs. But that force is so high that it's just uncomfortable for my wrist. We talked about coupling this time and not so much with pitch but it seems to be with roll. If this is the same setup that I had for the first run, this is going to be an interesting contradiction, but it seems to me that my problem now is more coupling with roll than pitch. Probably the reason for the rating is once again the excessive forces and coupling with roll.

RUNS 377-382 Pilot 7, TGSSC, .48in-lb DB, 6in-lb/g, WLT

I give this one a 3 and I want to say that I felt good about the large amplitude corrections and real good about the fine corrections. I think I solved the problem during the roll. I don't think I'm putting cross coupling in with the side force input, twist input.

RUNS 383-385 Pilot 7, TGSSC, .48in-lb DB, 48in-lb/g, WLT

I can make fine corrections pretty good. It's a little harder on the big ones.

4. The reason is excessive forces and it's causing me to frequently find myself and my elbow moving all around. My forearm is off the rest and I think that it's interfering with the large

amplitude corrections that I was making. Fine tuning I can do reasonably well. I think it seems to me I had more pitch problems this time than I've been having lately. I didn't see the roll problems that I was talking about before. Don't know the reason. But the biggest reason overall for the 4 is the fact that I'm moving my arm all around which I don't think is the intent of the sidestick controller and I don't like my ability to make the large amplitude corrections.

RUNS 386-389 Pilot 7, TGSSC, .48in-lb DB, 36in-lb/g, WLT

Back to a 3. I think the force is less but still too much for me. I still was just displacing my elbow around the cockpit.

RUN 390 Pilot 6, TBC, .025lb DB, 5lb/g, WLT

I didn't see any problem with that. The first target, I rolled out to the left of the target and had to move right to hit the left corner of the runway. That took two moves because I stopped short a little bit and had to move back over. When I came in for the second target, the right side of the runway, it went right over there and stopped right where I wanted. That was no problem. I didn't have any problems with that. I'd give that a 2.

RUNS 391-392 Pilot 6, TBC, .125lb DB, 1.667lb/g, WLT

I was having trouble overshooting. I was having trouble getting it to stabilize down on the target. I went past it two or three times before I could come back and get it centered on the target.

Still having trouble with overshoots on that. I'm not sure if it's a lag or what. But I overshot the target two or three times trying to get back to it. It's not extensive effort. I'd give that a 5.

RUN 393 Pilot 6, TBC, .250lb DB, 1.667lb/g, WLT

Seems to be a slight amount of hesitation when I'm trying to go in or come out. That there seems to be a lag in what I was commanding it to do. Very slight but enough that it's throwing me off a little bit. I'd still go with a 5.

RUN 394 Pilot 6, TBC, .025lb DB, 1.667lb/g, WLT

Again it doesn't seem to want to stop when I tell it to stop. It continues on a little bit. That's where I'm telling it to stop and I'm having to stop early and then kind of just blip it over with the controller. I'm not getting the larger overshoots like I was last time. I'll go with a rating of 4.

RUN 395 Pilot 6, TBC, .025lb DB, 5lb/g, WLT

Response seemed a little slower that time. I might not have had full command yet but it seemed like the turn rate itself was lower.

That one went a little bit better because I was anticipating using a little bit higher forces. It was precise enough. It's just that the force on the thumb button was too high. I'm almost having to pull my hand off of the controller to get enough leverage to get this thing over. I didn't like that much at all. I'll have to go with a 5 on that.

RUN 396 Pilot 6, TBC, .025lb DB, 1.667lb/g, WLT

That was a lot better. I'll get you a rating here. I'll go with a 3. With the higher pressure that you had on the previous run, I'm almost having to contort my hand around the control in order to get enough pressure to get that thing all the way over for full deflection and that's screwing up my roll command, my angle of bank. That was part of the problems. With the lighter pressure I can just keep a normal grip on it and move the thing side to side with just my thumb.

RUN 397 Pilot 6, TBC, .250lb DB, 1.667lb/g, WLT

I didn't see much difference in that and the last one. I'd go with a 3 on that.

RUNS 398-399 Pilot 6, TBC, .975lb DB, 1.667lb/g, WLT

If anything, that might have been a little too light. I was trying to make small corrections and I was having trouble making the small ones. The first target, I brought it over and I overshot. When I tried to come back I overshot again because I put too large a correction into it.

No large problems. I don't notice any appreciable deadband. It seems to be moving when I tell it to. 3.

RUNS 400-401 Pilot 6, TBC, .125lb DB, 1.667lb/g, WLT

I didn't notice any appreciable lag in the command and I didn't have any trouble keeping it on the target other than a slight amount of bank that I introduced into it myself. I didn't think that was bad. 3.

RUN 402 Pilot 6, TBC, .5lb DB, 1.667lb/g, WLT

I seemed to notice just a small amount of lag that time in my control inputs. I was having to put a small amount of pressure against it before the airplane started to move. I give it a 4.

RUN 403 Pilot 6, TBC, .375lb DB, 1.667lb/g, WLT

That seemed fairly easy also. I noted it seemed like just a hint of a hesitation over what it was before. Nothing that was not controllable. We'll give that a 3.

RUNS 404-405 Pilot 6, 2"RP, 7lb BO, 40lb/g, WLT

It seems to not stop when I neutralize the pedals. I'll neutralize the pedals and the airplane will keep turning a little bit.

I think what the problem is I'm having to put so much pedal in to get it to do something that it takes me a long time to get the pedal out of it. What that's doing is I'm not stopping it when I think I want to stop it because it's taking me a finite amount of time to get the pedals back to neutral. Give that a 5.

RUNS 406-408 Pilot 6, 2"RP, 7lb BO, 20lb/g, WLT

I've been trying to put in a command, take it out and let it drift to a stop. It seems the quickest way to do it. If I slow down and try to use a slower rate then it seems like it's taking too long for it to get over the target and I'm running out of altitude.

I'll try it using a slower rate next time and see what happens.

If I use that slower rate it seems like I run out of altitude. What I've been trying to do is move it over as aggressively as I could and still maintaining control.

I made one slight change here. I moved the pedals forward a little bit. It seems to make it a little easier to control because I'm doing a lot more of the work with my ankles as opposed to moving my legs back and forth. That wasn't bad. Seemed to be a little bit of a lag like there was a little bit of a deadband in there before I got any motion out of it when I started feeding it in. For the most part it took me two motions to get it on each target. I wasn't able to just bring it over once and stop it on target. I'd say that's a moderate compensation. We'll give that a 4.

RUNS 409-411 Pilot 6, 2"RP, 4lb BO, 40lb/g, WLT

I again saw a very slight amount of hesitation there. However, it was controllable. I was having a little trouble getting it stabilized on the target. I think that was because I had some bank into it. That one didn't go as smoothly as the last one did. I would have to go with a 4 on that.

RUNS 412-413 Pilot 6, .5"RP, 7lb BO, 40lb/g, WLT

That seemed a lot easier to use because I'm not having to make as large a control input. It also seems to be easier to stop it where I want to stop.

Rolled out right on the right-hand target so I went ahead and went to the left-hand target first just to get some motion in there. Didn't seem to be any problem moving it back and forth where I wanted it. I'm using pretty much full pedal deflection. The quickest way to get it over there is to use full pedal deflection and then let it slow down and stabilize out on the target. The short pedal travel facilitates that. That was fairly simple, I'd give that a 3.

RUN 414 Pilot 6, .5"RP, 4lb BO, 40lb/g, WLT

The turning rate is there but it seems like I had to put in a little more pedal to get it to start. A little bit higher forces to get it to start moving. Consequently, when I was trying to make small corrections, I was feeling for it and had to put in a little more pedal before I could get it to move. I'd give it a 4.

RUNS 415-416 Pilot 6, .5"RP, 1.5lb BO, 40lb/g, WLT

I've got adequate turn rate and it didn't seem like I had a lot of free play in there. I think I just got off because I was banking the aircraft instead of keeping it wings level.

One of the things I noticed on this you have to keep the wings absolutely level if you've got the least little bit of bank in there it pulls the pipper off the target.

What I'm talking about is I'm pulling the pipper off the target. If I just let go of the stick and I've got the least little bit of bank, it will pull the pipper off the target to one side or the other. The airplane is turning. It seems to be very sensitive to any bank angles at all.

I'm having difficulty keeping it on the target and I'm not exactly sure why. It seems like it is taking a lot of small pedal movements to keep the thing centered on the target because I'm wobbling off one side or the other.

It seemed like I was using four and five pedal motions just to keep it on each target, I would go with a 5 on that, considerable effort.

RUNS 417-419 Pilot 6, .5"RP, 1.5lb BO, 40lb/g, WLT

No problem on the first target at all. It just came right over and landed on the target. The second one -- when I came to the second target it seemed to overshoot a little bit, took two or three pedal motions to get it back on and then I was off a little bit in pitch but that has nothing to do with this.

I'm having a little problem getting it to settle on the second target and I'm not sure exactly why.

I didn't see any problem with that. It seemed to come out and settle on the target okay. I think I was using smaller commands going from the first to the second target than I did last time. It seemed to work out a little smoother.

I'd have to go with a 3 on that.

RUNS 420-421 Pilot 6, .5"RP, 4lb BO, 40lb/g, WLT

Smaller corrections seem to be working a little bit better now.

It seems that when I go to the smaller pedal inputs, it's coming over a little bit smoother. I'm not getting as many overshoots as I was before. Probably the added amount of time it takes to drag it over the slower speed is worth it because you are not overshooting and having to correct back for it.

That works a lot better doing that with smaller amount of pedal input. I didn't see any problems with that at all. I'd have to go with a 2 on that.

RUN 422 Pilot 6, .5"RP, 1.5lb BO, 40lb/g, WLT

I didn't have any problem with that at all. I'd have to go with a 2 on that also.

I think the last couple that we've had are probably about the best we've seen, least amount of effort I had to do on any of them.

RUN 423 Pilot 7, TBC, .025lb DB, 5lb/g , WLT

Adequate performance not attainable with maximum tolerable pilot compensation. I don't like this thing. What I don't like is I'll make my comments in order here in a minute, but I do not like having my thumb up there. My thumb needs to be on the side of the controller. I found during the past that I had to adjust my hand position to control the stick and then move back to the side force and hold the stick -- kept changing my hand position. I'm going to give it a 7.

The forces and all that, I don't think the forces are too bad. Sensitivity no problem. I found that in order to make a pitch correction sensitive as I wanted, I had to stop playing with the isometric and I had to drop my thumb down off of it to control the pitch and then if I needed isometric input I had to regrip the throttle and put my thumb back up there. This does not impress me. Maybe it's my hand.

That time I was gripping the stick pretty high up and the main joint in my thumb I had in the center of the button, which makes my bottom three fingers too high upon the trigger guard.

<u>RUNS 424-428</u> Pilot 7, TBC, .025lb DB, 2.5lb/g, WLT

I really think that I'm having to make discrete pitch corrections and then make a discrete side force and correct pitch -- I can't control both of them at the same time the way I'm holding the stick.

That time I was getting close to making both the pitch and side force inputs at the same time.

I did something a little different there. During the roll I tried to use the button and that's when I'm inserting the most stick the most force, lateral force, I don't think I'm as good at that compared to the other controllers. By putting a lot of lateral force in, the accuracy of the isometric inputs suffers.

When I roll right I feel like I need my thumb down there to get a little force on the sidestick.

A big 5.

The forces don't bother me, not that time, but I'm still bugged by having to readjust my hand on the grip to do what I want to do. If I want to make gross movements I have to use -- I don't feel like I have sufficient authority in the stick so I frequently drop my thumb down around the stick and then put it back up. Of course, when I drop my thumb down, I'm not using the side force, when I come down the chute. When I want to make fine changes, I can put my thumb back up and have enough authority with my hand and do a reasonable job of making the fine adjustments. However, I still feel that there is a problem with making a coordinated pitch and side force change at the same time. I tend to make discrete changes and one axis at a time which doesn't prove very effective.

<u>RUNS 429-431</u> Pilot 7, TBC, .025lb DB, 1.667lb/g, WLT

Not only do I have trouble with the big corrections, I'm not that happy with the small corrections.

Forces I don't have any problem with. I'm dissatisfied with the accuracy -- major reason for a 6 -- that I'm getting in the fine acquisition. I feel like ... I know that I've got a lot of scatter on my bullets there. It's possible I'm trying to be too aggressive with it, but I think I'm responding with the same amount of aggressiveness as I did with other controllers.

I think I am pretty much giving it full command everytime I go gross.

When I'm in the gross acquisition, I like to, at the same time, think I have full stick authority, by that I mean side stick authority and I don't feel comfortable saying that I have full stick authority available if my thumb is stuck straight up in the air.

RUNS 432-433 Pilot 7, TBC, .025lb DB, 1.25lb/g, WLT

I give this one a 5 because I've improved the fine acquisition. Comments I made before about gross acquisition are the same.

I don't like making gross acquisition with my thumb up in the air. I like to have my thumb around the stick, sidestick when I'm making gross acquisition maneuver.

RUN 434 Pilot 7, TBC, .025lb DB, 1.667lb/g, WLT

I'll give this one a 5.

The basic reason is I feel -- the reason I'm not getting any higher rating than this is because I'm not satisfied with the fine acquisition and I don't -- I'm not able to use the button during roll, for example, the gross acquisition phase -- let me try to make you understand that a little better. Before when I was rolling I felt comfortable using a side force input with the isometric, I don't feel comfortable using it until I'm wings level. That's what I'm trying to say.

RUNS 435-437 Pilot 7, TBC, .250lb DB, 1.667lb/g, WLT

A 4. You've got to learn how to use this thing.

I felt like the fine acquisition was better. I'm having trouble with the lead. I have a rate established making a correction and I wouldn't take the rate out at the right time and as a result tended to overshoot when I was putting in a fine correction.

I don't think I'm as accurate ... for example, when I'm straight and level sometimes with this button, I feel myself causing an input that I didn't realize I was putting in.

RUNS 438-439 Pilot 7, TBC, .500lb DB, 1.667lb/g, WLT

4 again. However, I felt like the problem I talked about last time with being unable to judge rate was not quite as bad. By not being able to judge rate, I mean unable to -- well, I didn't have the problem with overshoots that I was having last time, when I was making a fine acquisition pass. I was able to lead it better.

When I'm coming across is when I have the problem with judging the lead.

I might be walking the gray line between gross and fine acquisition. I'm calling the last part of gross acquisition a fine acquisition maneuver.

With respect to undesired inputs, I'm getting more comfortable with not having my hand wrapped completely around the sidestick. What I'm really saying is my learning curve is scattering the data.

RUNS 440-442 Pilot 7, TBC, .125lb DB, 1.667lb/g, WLT

I think I'm unable to discriminate differences in feel on the old button there. I'm not able to tell whether I'm moving it, using more force or less force.

I don't like it. Give that one a 6. I can't tell you what the problem was.

I think once on target it was hard making the fine acquisitions, the fine corrections once you are very close to the target.

If I had turbulence I would have been all over the place, I think. A little bit off the target and I tended to---it took extra work to correct that.

RUN 443 Pilot 7, TBC, .025lb DB, .833lb/g, WLT

This is different!

I think that I'm putting a correction in on the thumb button and when I let go of the button it is not zeroing out. Either that or it's decaying out real slowly. (No pilot rating given)

RUNS 444-446 Pilot 7, TBC, .050lb DB, .833lb/g, WL

When I'm straight and level it's real easy to tell where that force is going to zero when I let go of the button or not.

I'm really -- I'm not making any distinctions between the gradients today. The root of my thumb is uncalibrated.

I don't really know what's going on here. 5. That time I was making inputs and they almost--had a degree of randomness to them and I was unsure what input I was going to get until I observed it outside. I don't know how to explain that.

I was making inputs and sometimes it felt like it was more than I wanted and sometimes I got less than I wanted.

Just a hair sensitive for a thumb.

Maybe that's it. I don't know if that's the answer or not, but I know what the problem was. The problem was the input I thought I was putting in were not necessarily coming out as outputs.

<u>RUNS 447-454</u> Pilot 8, 2"RP, 7lb BO, 60lb/g, WLT

I like it better without the motion. The motion kind of makes me sick.

I thought for me that was a little -- you could control it with no problem but I like lighter forces.

It's not the problem with the tracking with the rudders I have, it's the trouble with the pitch.

I don't suppose you'd accept a 3 and a half, would you?

I would say it's a 4, minor annoying difficulties, desired performance requires moderate pilot compensation. It's the pitch that's sensitive. I'll stick with a 4 and see what happens from there.

<u>RUNS 455-459</u> Pilot 8, 2"RP, 7lb BO, 20lb/g, WLT

On the first shot that's definitely better than the other one. The rudder pedal forces were much lighter.

I got three of them in that time. I like that a lot better.

Also, it seems like I don't have to use as much displacement with the higher rudder pedal forces, I have a tendency to push the rudder pedal all the way to the floor, with the lighter rudder pedal forces I only -- I seem to have a tendency not to push the rudder pedal in as far.

I think I'd give that a 3.

<u>RUNS 460-461</u> Pilot 9, 2"RP, 7lb BO, 6lb/deg, AZP

On the initial rollout there was a mental confusion on my part between the gun pipper and the aircraft symbol and didn't realize it until after I started to pull the trigger. For the second and third shots I had cleared my confusion.

I also felt like that is still a little bit too rubbery, a little too -- not enough damping for me, preferential-wise. Seemed like I needed too much in the way of reverse rudders in order to try and stop the oscillations, lateral oscillations. When that happens, I also feel I need to put in aileron corrections which kind of throws me off any kind of effectiveness that I would have had otherwise with pointing, so it seems to be doubly important to have that correct feel in the rudder pedals.

On the last, on the fourth one my trigger pull was actually rated off the target as I started the pull up. First three were fairly distinct trigger pulls and on the target.

Following the format on the pilot comment cards, starting off with the Cooper-Harper, I feel it is controllable, and actually I would have to say it is not adequate performance attainable with a tolerable workload and I would say that because of what I perceive to be too much rating as I try to point at the target. I don't feel like I have enough of the rating taken out to have good solid shots.

When you fire 20mm or 40mm shells out of an aircraft, if there is any rating on the aircraft at all, by the time you get -- by the time the shells travel 5000 feet you are not going to have an effective shell and my impression was that I could get within a circle, but even once I had gotten there, there was enough rating of the aircraft pointing instead of stable on the target or even stable near the target in the case of some sort of high incendiary shell that could do damage anyway. I had enough rating either longitudinally, laterally or both, that I don't think in the firing mode, the gun mode, I would have been effective. I don't think I would have hit the target and secondly even if I were close, I don't think that with the rating I had in the pointing the gun towards the target that I would have been able to do any secondary damage by having a good stable platform for the shells to at least hit pointing in first without starting to tumble, say after 5000 or 6000 feet of travel. On my particular talents for this type of a task, I guess I would have to say the system is not good enough to make up for my inability to steady the aircraft into the present configuration. So I guess I would have to go into the 7, 8, 9 type category. I felt like I was trying very hard, especially on the last run, so I guess I could say adequate performance still not attainable with as good a job as I felt I could do even though I felt like controllability was not in question. So I guess overall 7 there.

Proceeding down the commend card, concerning control feel characteristics the forces did not seem objectionable either high or low and that may have been -- well, I seem to be preoccupied with the sensitivities. The harmony was not a question so I don't feel like any one axis was overbearing another. Displacements didn't seem to bother me other than how I seem to use overdisplacement in the rudder pedals because of what I felt to be kind

of a slow -- now wait a minute, slow but undamped type feeling in the lateral motion. The sensitivity was certainly there though and not necessarily objectionable except that with the sensitivity it didn't seem like there was enough damping laterally for me to put in small inputs, take advantage of the sensitivity and then be able to use a force that was equivalent to the high sensitivity in order to move the gun pipper to the target and be able to stop it on the target, no rating, fire the shots. I really had no feeling one way or the other about the authority, I presume it must have all been there in that I felt like I had enough to move from one target to another and then from one far target to the third target although in order to bring off the last gun burst for the fourth target back in the center, I was having to hurry myself, I don't think that was a function of the authority though. Roll control I find adequate, I feel like even though at first when I started off I felt a little spastic using it. I feel like my perception is that it seems to be getting better. Directional control I find to be objectionable in that I don't feel there is enough damping to help me smoothly move from target to target with an appropriate amount of foot pedal force and travel. Pitch control I have no argument with, that seems to -- the forces seem to be neither high nor low. They just seem to be right.

Moving down to No. 8 on the comment card for this particular run, my primary reason for the rating is that in that I don't consider myself a polished fighter type pilot, or a bomber pilot in a small aircraft, really. At least a gun -- an air-to-ground type pilot. I feel like the system would have to be unusually good and because my workload was so high and I was still unable to at least steady the platform enough to take the rating out that I think due to my own inabilities to come up and be able to take out some of the items in the lateral mode, don't think that the system as it is with me in it would be good enough to be an effective air-to-ground firing machine. There were no simulation limitations that I was aware of.

<u>RUNS 462-466</u> Pilot 9, 2"RP, 7lb BO, 14lb/deg, AZP

On the stick grip I have the fatty part of my thumb inside of my thumb on the rear of the stick and I have my middle two digits loosely wrapped around the inside of the stick, I have my forefinger and my little finger a little bit curled but not hugging around the stick and I seem to be making force movements in the stick either with the kind of a rotary motion about my wrist and the forces seem to be coming from either the butt of my thumb or the middle two inside knuckles of my hand and then opposite motions from my two middle fingers if I need to go outboard.

I lowered the forearm rest probably three quarters of an inch.

I seem to feel like there is a little too much lag now in my lateral input until the time I see a reaction. Still feeling a little bit of jittering around the target once I'm in the general vicinity.

You might want to do a little bit of something or other on this shoulder harness. It gets to where -- I can't release it a little bit, it's pretty objectionable sitting in the seat. Referring to the Cooper-Harper scale, that run was controllable. I think from the last two runs I would say that the performance is adequate a tolerable workload for a person such as myself. However, I do think it still has need for improvement in that I still saw probably the remnants of that unstable pointing platform that I don't like to see or I wouldn't want to see if I were trying to put bullets on a target. Again from my own experience, you've just got to take the rating out of it. My experience is a side firing weapon, but I would be very surprised if it were any different if you fire forward or fire to the side. By rating I'm talking about the fact that it is constantly moving.

I only have a few moments when I need to be able to stabilize the platform and get off a short burst and I feel like maybe with time, I could compensate enough to take care of it but still for this day and this time and this rating, I would have to say that the rating that I still see makes it barely satisfactory and certainly requiring improvement for a person like me. I would say that it is -- I guess I'd have to go with 6. I still find it objectionable and I feel like I'm requiring too much of it in just to take care of that unstable motion and although I think I'm finally getting to the point where some of the shots might be effective. I don't feel like I could take on any other issues. I don't think I could handle a whole lot more mentally or physically, other than just putting the airplane straight down the chute and taking care of that task. I guess overall 6.

I'm just saying that mentally and physically, I still know there are other things to do and with that in mind I'd still have to say it's very objectionable. I don't think I can take it out of the context when I'm looking at how I feel about the objectionability of that task. Also, on the demands on the pilot, we are talking about an extensive pilot compensation. In other words, I feel like what is valid is that I'm having to take all my skills and point them into that one little aspect so that -- and the rest of the issues are kind of periphery issues which are causing me to find the objectionability and to be so cognizant of the extensive amount of my efforts towards this one task. I think I'd better stick with my 6.

I notice no objectionability in forces or displacements except that although it is not a harmony issue, the displacement didn't seem to fit the amount of force that I seemed to be having to put in and I think maybe I was getting that feeling because it seemed

like a severe damping on the lateral motion and more force and more displacement and finally I would see the movement of the aircraft so that would be my objection as far as the displacement issue.

Therefore, I think also 3 would have to take a hit, the sensitivity seems to be lacking again through the rudder pedal motion, I'm not getting a feedback or I'm not getting a feedback soon enough on my lateral inputs. The control authority seems like it should be adequate, it's just so....and I think that is a good way to start into No. 5. Roll control I find nothing objectionable, the directional control I do because of that slow reaction time and the pitch control again seems to be quite useful and I find it neither plus nor minus it seems to be just what I need. Like I said I guess I am compensating by still putting in -- although you made the comment that I shouldn't have to put in anymore aileron once I roll out, I feel like I'm having to compensate.....I guess on the summary comment, again the 6. Feels like to ask me to perform this task adequately and kill three targets, really kill one of the targets twice, the machine really has to be very good because I don't consider myself either an experienced or an adept type person for this type of a task, so I feel like although I know what I want to do and where I want to place things, I feel like I cannot compensate quickly enough for the system to be anything to really rave about. I do feel like over the first one now you are talking about maybe a reasonable amount of training time and I could probably bring the task into good enough performance so that those four targets are killed. Again, I'd have to -- I want to place a qualification on those ratings in that I feel like the machine is going to have to get a lot better to combine with me in order to make a good firing weapon.

RUNS 467-470 Pilot 9, 2"RP, 7lb BO, 10lb/deg, AZP

I felt pretty good about the first three and then I think if I had left it at that I would have been pleased with the way the machine seemed to be reacting then trying to add the fourth target to it I guess I increased my displacement in the forces and seemed to go beyond my own threshold of compensating and controlling to stabilize so overall it seems like -- the system seems to be getting better.

I found it controllable. I think it is adequate performance with a fairly tolerable workload. I think I'd still have to go with "No", as far as totally satisfactory without improvement. I would say because I still feel minor annoyances and again I think that with time I could compensate for it, but I would like to see a little more stability around the target. I may be nit picking now but I think the total effectiveness could -- either by someone that could compensate faster or that had a little finer touch on the rudder pedals, but for this guy I would still find it minor annoyance so I would give it an overall 4.

The forces, seem good, they seem in harmony in both longitudinal and lateral inputs on the stick. I feel like the sensitivity has taken a good leap towards the better, especially in directional control with the rudder. The other two axes, I don't really feel anything objectionable nor have I really sensed a whole lot, if any, changes in the sensitivity or authority. I feel like the authority issue on the rudder seems to be improving because I sensed a more responsive mode directionally when I put left and right rudder in. Roll control again fine. Directional control much improved again because of that perceived greater authority but I think it is not necessarily that much more as it is just the fact that I'm getting a closer response from the initial input from my feet. Pitch control no problem and I feel like I'm not having to employ any standby techniques or anything unique due to my own skills or lack of skill. So I feel like the machine is helping me more now and I don't feel as overloaded or as totally loaded with just the physical aspects of going through the task here and I'm also finding that with that I think I'm seeing more. So overall I'd go with a 4. And the only drawback that I'm doing that is that I still feel -- I'm still conscious of, as the term goes, minor annoyance of the stability around the pipper. I haven't answered this the last couple of times but I have not seen any limitations, simulation limitations, other than that I mentioned I wasn't picking up the target. However, I'm seeing now that as the system gets a little bit better, I think I'm seeing more and I don't know if it is just familiarity with the target area but I seem to be seeing it a little bit better.

<u>RUNS 471-472</u> Pilot 9, 2"RP, 4lb BO, 10lb/deg, AZP

I felt it was definitely controllable, and I think I honestly saw adequate performance with a tolerable workload for me. I think it satisfactory without improvement. I thought overall good with negligible deficiencies and I believe that I could see myself being rather effective regardless-or as effective as someone else and I felt like the machine was helping me quite a bit. Did not feel overloaded. Felt like my inputs were more definite. I knew where I was placing the aircraft.

I felt definitely in control of the pipper. I felt an awful lot better about the stability of the pipper on the target. The times that I stabilized a little bit off the target, I felt like that was something that I could work with and learn to be better at. The thing I was pleased with was the fact that I put it where -- it went where I put it, stayed there, I could make small corrections and just felt overall very good about it. For me on that one, a 2. The issue of forces, I'm still pleased with the forces. The directional forces on the rudder I don't think it is an issue of force, I think it is just ever increasing familiarity between myself and the rudders, so I think forces have not been an issue, I have no complaints. Displacements are fine. Harmony is good. The control sensitivity, my perception is that it seems to be getting better, especially in the lateral, obviously.

Control authority is sufficient. No objections. Roll control is fine, directional control is the best I've seen for my input to control, lateral pointing. Pitch control, I've seen nothing objectionable, nothing seemed to change. I was not aware of any special techniques: overriding techniques, or compensating techniques there other than just trying to do the task. So I would go 2 I think simply because just of negligibility and things that I think I can be taught to do better; I didn't do it perfectly but I think at this point the machine is good enough that you could teach a person like me to be awfully good at this task. So go with a 2 as opposed to a 1. Again, no effects, plus or minus on the simulation limitation.

<u>RUNS 473-474</u> Pilot 8, 2"RP, 7lb BO, 20lb/g, WLT

It's controllable, but I think I'm putting in quite a bit of effort into pushing the rudder pedal just where it has been difficult; the pilot workload is what I'm trying to decide on. It seems like every time I do it, it gets easier. Which is, it moves me from the 10 down to the 5. The first time I can't do it, the second time it's a little easier because I'm adapting to the system. I would say it warrants some improvement. I would say it's a 4, minor but annoying deficiencies, desired performance requires, I think it requires -- the first time it required extensive pilot compensation, now it requires moderate pilot compensation. I really have to concentrate on how much force I'm applying to the rudder pedals. I would say a Cooper-Harper 4. The feel characteristics of the forces are too light. Displacement, the first time I used full rudder pedal deflection and the next couple of times I used about half rudder deflection. The rudder pedal forces are too light. What the problem is the pitch seems to be the most objectionable for me. I guess that's not something we are supposed to evaluate.

It's not giving me a lot of problems, it seems like the frequency is too high. There is the damping -- seems to have too high a frequency or too low a damping, but I guess we are not evaluating right. The nose seems to bobble on me, when I put the nose down, I guess that's not important.

I've been concentrating on the pitch more than on the---the control of the rudder pedals and the changing the heading without my sideslip is a natural thing. It feels nice. The rudder pedal forces were a little bit too light but what I'm concentrating on is the pitch control more than I am the rudder pedals.

RUNS 475-477 Pilot 8, 2"RP, 7lb BO, 60lb/g, WLT

I was concentrating real hard on the pitch.

Rudder pedal forces feel a little heavy on that one.

On the offset, I think the rudder pedal forces for that are just a hair too heavy. Let's try it one more time on an offset. I think we've gone to the other side, they were too light before, they are too heavy now, so we are....

This one is controllable. Performance is attainable with tolerable pilot workload. However, I think desired performance requires moderate pilot compensation again. I give it a 4.

I don't know what the problem is. It's not the rudder pedal forces I don't think. We may need to lighten the forces up a little bit. I'm still concentrating really hard on the pitch and try to make--stabilize the airplane on the point, it seems like the, maybe it's the rudder pedal displacement. I used full rudder to get it over there because I was so far offset, it seems like it is easier when we are on the straight end and can use very small rudder pedal displacements to move the thing back and forth but when I had a large offset and I bring it over, I use a large rudder pedal displacement, bring it over and then as it approaches I overshoot it and then I have to bring it back and by that time I'm too low.

RUNS 478-485 Pilot 8, 2"RP, 7lb BO, 40lb/g, WLT

This time I only used just a little of pedal. I can walk the nose back and forth across the runway, I could have probably gotten three of them in there, depending on how long I stabilized on the point.

It feels like I'm inside a basketball.

Once I started doing it the way you wanted it done, it was a lot easier. It's controllable, it's adequate performance, it's attainable with tolerable pilot workload. Right now it's to the point again where I'm calling it a 4....It's not minimal pilot compensation it's moderate pilot compensation, somewhere inbetween there because each time that I tried....

I'm going to say a 4, I think the rudder pedal forces are just a bit too heavy and desired performance requires moderate compensation. I think it is because my rudder pedal forces are too heavy, I'm having to--what I do is when I push if I have to think about the push, then I concentrate on how hard I have to push. If they go in and I don't notice the rudder pedal to the point--if I don't notice the rudder pedal forces to the point where they are too light and I overshoot, so I would call that a 4. I think I had too light on one side and now it is too heavy on the other side. I think it's a 4, let's call it a 4.

RUNS 486-488 Pilot 9, 2"RP, 7lb BO, 10lb/deg, AZP

First from the Cooper-Harper, it is controllable, it is adequate performance with a tolerable workload. It does need improvement. I'll go with a 5. Moderate objection and it's in the longitudinal mode. Feel good laterally with the rudder movement. Longitudinally I seem to be acquiring the same kind of instability that I had in past situations with the lateral mode. I'm finding it a little bit too sensitive, not damped enough in the longitudinal. Overall 5. I don't know if that's just warming up here on the first run but...

No negative comments on Item #2 other than--well, none on 2. The same comment on 3 longitudinally, or at least perceived. Four is nominal 5 charlie seems to be too sensitive.

I was adding pilot techniques to try to dampen myself on longitudinal.

For the pointing mode I'll go all the way to a 2, and the negligible deficiencies are the minor irritant would just be striving for a perfect stability and I feel like there is still a little bit of jitter.

RUNS 489-493 Pilot 9, 2"RP, 7lb BO, 14lb/deg, AZP

I felt much better about that run, even longitudinally. I guess tending more towards the 2 than the 5.

I'm feeling better and better about that one. Last two runs I felt pretty good about. Really not even minor irritants.

Cooper Harper, it is controllable. It is adequate with a tolerable workload. I think it is satisfactory without improvement and overall I didn't feel myself adding any compensation, I guess I'm ready to go all the way to a 1. I have no negative comments.

RUNS 494-497 Pilot 9, 2"RP, 4lb BO, 10lb/deg, AZP

I felt the task was controllable. I guess I'd have to drop down and say I didn't think my performance was adequate. Tolerable workload. I think I would go to a 7. I did not think the performance was adequate with my compensation. The forces seem to--force gradient seemed to change and it seemed to take a rather large rise as I put in increasing increments of rudder. Initial rollout and fine adjustments seem to be okay. Target No. 1 was all right. Even a little bit towards Target 2, but then I noticed that the little bit of that lateral instability came back plus it seemed like the forces were foreign to me and I did not like the gradient. It seemed to be too high at large ever increasing amounts--increments delta increment that I added on the rudder.

RUN 498 Pilot 9, 2"RP, 7lb BO, 18lb/deg, AZP

It is controllable. I did not believe that adequate performance was attainable with tolerable work load and I would again go back to an overall rating of 7 in that I--adequate performance being to be able to get to all four targets, I started off initially felt good about stability around the first target and got to the second target but there seems to be a lag in the authority of actually pointing the airplane after input of the rudder and I'm trying to compensate for that by increasing the rudder deflection whereas I ought to be able to stabilize on all four targets which I have done. I don't feel like I have,--I feel like there is too much of a lag and the force gradient is too much to be able to tolerably move to each target, stabilize and shoot. I'd have to say that I did not attain an adequate performance and I was trying to add both extra pilot compensation and fairly high work load and not being able to do it. So overall 7.

RUN 499 Pilot 9, .5"RP, 7lb BO, 1.5lb/deg, AZP

Didn't like that either.

I think I can rate it. Aircraft is controllable. Adequate performance is not attainable at tolerable pilot workload. I would say it would go to an 8, considerable pilot compensation is required. It would be on the 8 plus side. I felt like for fine corrections, I think it would have been all right, the first target seemed to be all right. Even maybe the second target, the lateral stability seemed to be okay and the inputs did not seem to be objectionable, but going from target 2 to target 3, the system showed itself to be seemingly inconsistent in that the input and resulting motion and stability going to the third target left me totally and then at that point trying to jump in with a different type of compensation, I did lose target three and four. I guess another thing besides considerable pilot compensation, I guess I'd also have to say that it was confusing that compensation seemed to have to change in order to get an adequate performance. The confustion I think would add to the all ready workload at that point. You couldn't get the kind of performance out of me that you'd want.

Item 1 - overall 8. Item 2 - control feel; I don't like small displacements. That doesn't seem to show up on fine tuning for the first couple of targets, especially if they are close together because my tendency is to use smaller corrections to move from one target to another. Between target two and three my task is to go quite a ways in a short amount of time and my tendency is then to try to put in a larger input to make that change more rapid. The sensitivity seems to be good. I seem to feel like I'm getting a response laterally when I put in the rudder, given that I still don't like a small displacement. My authority seems like it should be adequate at the small corrections but although the authority allows me to go all the way to say targets that are spaced the entire span of that runway that you have the

two extreme targets placements, in trying to take care of that particular subtask, the directional control is objectionable because I seem to have to change my compensation and in that I'm putting in what I feel to be a greater deflection and a greater force in order to move the pointy end of the airplane over to the target. In doing so, I don't get the same kind of stability that I was expecting from what I had to go on and my initial pointing subtask at targets 1 and 2. So inconsistency is the manifestation and the actual complaint is the instability about target 3 and 4.

It's kind of a gradient, if you will, of compensation. I'm getting what I think to be an inconsistent change in compensation as I go from target to target at increasingly spaced lateral separations.

I really don't like short displacement rudder pedals.

<u>RUNS 500-501</u> Pilot 9, .5"RP, 7lb BO, 3.5lb/deg, AZP

Controllable, did not believe we had adequate performance with tolerable pilot workload. I think an overall 8, considerable pilot compensation is required for control and I say an 8 only because I think it is partially effective again duplication of my comment on the first target because there seemed to be small corrections required only and with just small inputs to the rudder I feel like the aircraft can be placed in control without a whole lot of jitter. Seems like--maybe a way I can describe it, as I try to maneuver more I have an almost feeling of divergence of the directional stability of the aircraft. Small correction seems to be okay and controllable, but once I try to load up the task and move the nose quickly at displaced targets, then I get the feeling like the tendency is a divergent one and totally ineffective on subsequent targets. Again, I guess I'd have to add my personal comment, I don't like the idea of short travel rudder, at least that is my feeling right now. I feel like that is adding to the difficulty I'm finding in trying to compensate and then I'm substituting--I'm overcompensating with force mentally trying to overcome this short throw of the rudders and then I'm adding to my own difficulty in that stability issue.

I don't really get a force feedback after small corrections. I don't find anything objectionable in making the small one or two pipper width type corrections. But then I feel like I'm hitting that wall and I'm increasing the force but I feel like I'm working such a stiff gradient that I don't have a feel for what is the required amount of force to make the kind of correction I want to make from the farthest displaced two targets. I find the force gradient or the perceived gradient too much. Those displacements you already know, I'm not an advocate of the displacement that you have me on right now.

Therefore, my harmony also takes a hit, I feel like the rudders are not in harmony with the other two axes.

I guess I'd also have to throw sensitivity in there too. I no longer feel a sensitivity for rudder. I guess I kind of lose it all.

RUNS 502-504 Pilot 9, .5"RP, 7lb BO, .5lb/deg, AZP

I thought the aircraft was controllable. I'm having a hard time on I'm going to define adequate performance to be able to hit all four targets. I'm going to say that adequate performance was not attainable. I'll go with an overall 7.

Duplication of comments I've had before in terms of the confusing aspects of the short throw, a little bit of a lag on the lateral nose movement for an input with what seems to be an objectionable high force gradient and the lateral mode. With that though, I'd asterisk it and say I could probably, with more practice, pull it up into the 4, 5, 6, category but right now with this initial look at it I'd have to leave it down there at 7.

RUNS 505-506 Pilot 9, .5"RP, 7lb BO, 1.0lb/deg, AZP

I would have gone on to successive targets but if I can't stabilize--the first target is easiest to stabilize, if I can't get that one, then I can start grading it from there. I am using four targets as the attainable--as the project that this workload is trying to get to.

Aircraft was controllable. Adequate performance was not attainable with the pilot tolerable workload. I would have to go ahead and give that one a 9 in that there would have to be an intense amount of pilot compensation required--I should say an intense amount of my compensation required to obtain adequate performance. Overall 9. I didn't have a sensation of forces. I had a sensation of loose pedals with short stops. So now I not only don't have a feel, a force feel, but I'm compounding that with the short throw which is totally the two worst combinations that I can think of. I guess what would be worse is no travel at all. I had no rapport in terms of sensitivity or authority with the rudders. All I was doing was jittering back and forth, I would not have even destroyed the first target again, the rating of that nose would have totally ineffectualized any firing instrument. Directional control, I'd have to give it bad marks and the special technique, I was just working as best I could to try and get it somewhere close and freeze it, but that always leads to PIO in the lateral or in any axis really that is in question. As long as you are in a PIO, you'll never be effective with a gun. Overall 9.

RUNS 507-508 Pilot 9, .5"RP, 7lb BO, 2.5lb/deg, AZP

The aircraft was completely controllable. I think adequate performance was attainable with tolerable workload. I would go--I think it could be improved so I think it warrants improvement,

although I would give it a high rating within that subcategory and go to 4 and call only minor annoying deficiencies. My impression was I got the feel back as far as the force gradient, seemed to be consistent. It helped me in the tactical senses of rating the aircraft to a point pointing at the target, so I had that sense given back to me so I thought I was more in control of the input and the desired output and was able to be a better predicter. I think I would still do better if I had an increased rudder throw. I think what that would do for me is it would give me still further better feel for the amount and the force required for the input. I put that rudder pedal throw and the force gradient, I put those very close together. I believe I used them together. Overall 4. Displacement I'd still like more. Forces I liked. Directional control much improved, not so much pilot compensation--perceive pilot compensation required.

<u>RUNS 509-510</u> Pilot 9, .5"RP, 4lb BO, 2.5lb/deg, AZP

The aircraft was controllable, adequate performance was attainable with a tolerable workload, the aircraft as configured is satisfactory without improvement. I think an overall 3 because I still perceived some minimal pilot compensation. Then going to the comment card, force gradient was good, displacement perception seems to be getting a little better. There is still a little bit more damping that would make me happy and the sensitivity or the jitter is still a little bit annoying for fine tuning prior to firing off the bullets. I guess the directional control has a minor annoyance towards the very end of the task in the fine tuning. Just minor. So special techniques would be a little bit of walking on the rudders--or a little bit of kind of touchy, just bare swamps on the pedal inputs to try and dampen out the little bit of jitter around the target. So I say overall 3.

<u>RUN 511</u> Pilot 9, .5"RP, 10lb BO, 2.5lb/deg, AZP

I think I would go to a 2 overall. What I thought I felt was a little bit of additional damping in the additional mode, everything else was per the previous run as far as the good comments and to take away one negative, I no longer felt the requirement for quite so much fine tuning at the very end. I felt like I had an adequate amount of damping in the system that I could adequately stabilize on the targets. So I would go to a 2 and the only reason I would not to go a 1 is--I don't know how to go from a 2 to a 1, I don't know what that would be.

<u>RUNS 512-513</u> Pilot 9, .5"RP, 20lb BO, 2.5lb/deg, AZP

Aircraft was controllable. Don't believe we got adequate performance and think we go with an overall 7. Adequate performance not attainable with a maximum pilot compensation. It was confusing. It's like the gradient changed in sensitivity. Let me just go down the cards. No complaints with forces. The

displacements, well I just don't know. Seems like an inconsistency was very--was an inconsistent feedback I guess and the combination of force seemed to be a little bit of lag to the response to an input. Seemed to be enough authority but it was slow and then it seemed like there was a change in the sensitivity gradient as far as the actual jitter of stability about the target, which caused an increased amount of time to try and stabilize about each target thus manifested itself in not being able to stabilize on each target to effectively fire off a burst.

RUNS 514-516 Pilot 9, .5"RP, 1.5lb BO, 2.5lb/deg, AZP

The aircraft is controllable. I think performance is adequate with tolerable workload. I think it could use improvement and I'd give it an overall 4. Minor annoyance, seems to be initially in rolling out on the target, minor corrections and seem to be able to stabilize and shoot off, then going to the second target, for some reason seems to be a little bit of instability in stabilizing on that second target. An overall 4, forces are good, displacements are better. For some reason, going to that second target, directional control gets a little bit jittery, a little bit too sensitive, and doesn't seem to have the predictable amount of damping for the input, but then nonsuccessive targets, it seems to, the perception is the correct amount of damping and the input, the forces and deflections all seem more tolerable, so I guess it is just the annoyance on the first change from Target No. 1 to 2. That was the only place that I perceived any special techniques.

RUNS 517-518 Pilot 8, 2"RP, 7lb BO, 60lb/g, WLT

It was controllable, adequate performance attainable with tolerable yes. It is satisfactory without improvement? I liked it. I think it's a 3. Minimal pilot compensation required for the desired performance and I liked the rudder pedal forces. I think they are nice, I really like them. I'd give that a 3.

RUNS 519-521 Pilot 8, 2"RP, 7lb BO, 20lb/g, WLT

Toss up, it could be a 2-1/2.....

I'll give it a 3.

Maybe the rudder pedals are just a little bit too light.

I had no problem accomplishing the task.

Again the rudder pedal forces may be a little light.

The task of performing the pointing with the airplane I could put it on the right, the left and then the center and didn't have any problem doing it. I could hold it there for a period of time.

Rudder pedal forces again may be just a little too light, but the task is a 3 or a 2-1/2.

If a guy didn't have a thumb, he couldn't fly this airplane. I stayed longer on each target than I did the last time. The task of performing it to put it within say 50 feet of where you want is a 3 to a 2. Rudder pedal forces may be a little bit light, but who am I to say, I like light forces, light to medium forces. That's the only thing I can see. I did have trouble with the pitch. I don't see any negative G's on my G meter ....

With that one I'd give it a 3. The rudder pedal forces were a little bit light I though, just a hair heavier and for me it would be ideal. I think it takes a minimum pilot compensation, however, I guess I wouldn't want to have to be doing something else, like talking on the radio or maybe dialing up another system. You know what I mean? For me to perform that task, I can perform that task with minimum pilot compensation.

A 3.

<u>RUNS 522-524</u> Pilot 8, 2"RP, 7lb BO, 60lb/g, WLT

Just a little heavy on the rudder pedals that time, but again the task is an easy 3. I'm not using full rudder pedal deflection at all, just about one third of the rudder pedal deflection available.

Little heavy on the rudder pedal forces but the task is easy, I can accomplish it without spending a lot of time. Again, I wouldn't want to have to be tuning a radio when I'm doing it or...

I can do it every time. What I'm doing is trying to fine tune for me, I think the rudder pedal forces are a little heavy, I could still do it, and I would still give it a 3.

I just have to push harder that's all. I can do it with heavy rudder pedal forces, I can do it with light rudder pedal forces, the light ones have a tendency to cause me to overshoot.

I think--I like that, I think it's still a 3. Minimal pilot compensation required for desired performance with the rudder pedal forces just a little bit too heavy.

I think the ones with the lighter rudder pedal forces I would switch that to a 4 rather than a 3. As I see more of them my mind starts to tell me that I'm having more trouble with the tracking task as the rudder pedal forces get lighter.

Make it a 4. The rudder pedal forces were just too heavy, I had to concentrate on pushing in on the rudders, they are just too heavy. I think they need to be lightened up a little bit and I think we'll move through an area where it will come to a 3 and then possibly go back to a 4 again because the rudder pedal forces get too light.

RUN 525 Pilot 8, 2"RP, 7lb BO, 100lb/g, WLT

That's a 4 on that one. Rudder pedal forces way too heavy. Let me see what a 5 is. It's moderate pilot compensation with the heavier rudder pedal forces. A 4.

RUNS 526-527 Pilot 8, 2"RP, 7lb BO, 40lb/g, WLT

I liked that one. The rudder pedal forces felt light to medium and I liked it.

I liked that. That one felt good. Give it a 3, rudder pedal forces were maybe a hair light, but they were okay.

I just thought it was easy to accomplish, even with the offset it was easy to roll--get the nose down and walk the nose one point to the other with the rudder pedals.

RUNS 528-529 Pilot 8, 2"RP, 7lb BO, 20lb/g, WLT

I had trouble with that one. I'd give that a--seemed like it took more displacement of the rudder pedals to accomplish the same task. The rudder pedal forces were too light. I'll give that a 4, 4 to a 5. I don't know.

It was controllable. Is adequate performance attainable with tolerable pilot workload? Yes. Is it satisfactory without improvement? No. It seemed like it took more rudder pedal deflection to accomplish the same amount but the rudder pedal forces were too light. It took a moderate compensation for me to stay on the target, it seems like I overshot and it might have been because the rudder pedal forces were too light. It seemed like it took more displacement of the rudder pedal to get the same desired effect that I got before.

4.

RUNS 530-533 Pilot 8, 2"RP, 4lb BO, 40lb/g, WLT

I like that. The rudder pedal forces felt good. I'd give it a 3. It's the pitch that bobbles. Of course, I told you that yesterday.

RUNS 534-535 Pilot 8, 2"RP, 10lb BO, 40lb/g, WLT

Had a little trouble with that one. The pitch bounces, when I'm offset I have to do more maneuvering in the roll than when I'm

straight ahead. However, the task of moving the thing around becomes more difficult in the offset than it does from the straight ahead. However, the forces--I would say that's--it is still controllable and its attainable with tolerable pilot workload and I'm still at a 4 or a 3. I didn't seem to see a change in breakout, it just seemed the breakout forces a little heavier.

I would give it a 4. It's moderate pilot compensation.

RUNS 536-537 Pilot 8, 2"RP, 20lb BO, 40lb/g, WLT

Rudder pedal force is too heavy for me.

I think when you do an offset that shows more too.

It was controllable and performance is attainable with tolerable pilot workload. However, the rudder pedal forces are too high. It took me a moderate compensation, a 4, to accomplish the task. Of course, the task is easier to accomplish when you are straight ahead rather than an offset and it takes more compensation for an offset than it does for straight ahead.

I'm closer, I have more time to get the thing over there and how can I say it. When we do a straight ahead run, I roll out and I don't have to hold the rudder pedals for a long time to get the thing over and I don't have to push in as much, I don't use as much rudder pedal displacement and I have less tendency to overshoot the target when I'm straight ahead because of the smaller amount of rudder pedal displacement that I'm using.

Once I get it over there, and I start working the target, pilot workload to work the target back from one side of the runway to the other side of the runway is fairly easy.

Once you get into a certain area, in a certain target range, within one or two runway widths, once I get into there, you can just put it anywhere with no problem. When you get to a point where you are 1000 feet or maybe 500 feet away, it's difficult getting it over and then you overshoot and it has a tendency to bobble back and forth trying to get it stabilized. If you start out inside a certain range, you can move it back and forth with no problem.

RUN 538 Pilot 8, .5"RP, 7lb BO, 25lb/g, WLT

I'm getting full authority with a half inch throw instead of half authority with the same amount that I'm pushing in. I was expecting before, I was getting half authority for the same amount of throw. I think it is a little oversensitive.

I don't think I like that short rudder pedal throw. It's not that it's not controllable, it's just---let me think about it a little bit. I'm trying to think with my mouth open.

Okay, I think I saw what I wanted to see.

It is controllable, adequate performance attainable with tolerable pilot workload. Is it satisfactory without improvement, NO. I find that .... remainder of comments lost. (No rating given.)

RUNS 539-540 Pilot 9, 3"RP, 7lb BO, 4lb/deg, AZP

I think I can go on this one. The aircraft is controllable. Performance is not adequate with tolerable pilot workload. Go with an overall 8. Considerable pilot compensation required. The reason for a Cooper-Harper 8, there seems to be a small force gradient in the rudder pedals and I think it is also--because of it I am further compensating even in the lateral mode with the stick. The roll mode in the stick, so I'm getting double negation there, on my inputs, just due to my own trying to compensate. I don't think that displacement may be a little too much, but I think right now the light forces and a lack of perceived damping in the pedals is causing this rating to go down to inadequate performance. Sensitivity seems to be good, roll control is okay except I'm overcontrolling as it transfers from my directional control which I do find inadequate. Special techniques, I'm overcontrolling in order to make up for the light forces which I don't have a good feel for yet and a light damping which is causing the aircraft directionally to vacillate around the target.

RUNS 541-542 Pilot 9, 3"RP, 7lb BO, 10lb/deg, AZP

I think I can go on this one. Aircraft totally controllable. Adequate performance is attainable with a workload, I would go with still want to keep--needs improvement. So I think I'm going to pop in with a--still with some minor annoying deficiencies that--Level 4, because I think I still have some pilot compensations in the fine tuning that is causing me to probably be a little bit close but I think still ineffective on the target. The forces seem much better now in the rudder pedals, there is a harmony of forces in all axes now that is helping me out. Displacements are good, negatively in the directional control there still seems to be a little bit of damping required or at least lacking right now and a fine tuning right near the target. I don't think it's a deadband, but I guess it may be, but it's an inability to fine tune directionally right at the target. It feels either like a deadband or a falling off of the damping right on the fine tuning point so that I don't ever quite really cut out the rating of the aircraft. Never really solidly home in on the target. Further on down there is a special pilot technique that I'm still trying to employ to dampen that out and I think in the course of that special technique of damping, I'm probably in most cases losing that fourth target. So overall 4.

RUNS 543-544 Pilot 9, 3"RP, 7lb BO, 6lb/deg, AZP

The aircraft is totally controllable, adequate performance is attainable and I think it is satisfactory without improvement. Go with an overall 2, I don't feel that there was any perceptible compensation that I was having to add. I guess it just stands alone. I guess if there were any problems or any shortcomings, possibly still just a faint jitteriness around the target but just almost imperceptible. Overall 2.

Just a comment on that left roll, right roll, I guess overall the last four days that's one thing that stuck with me as being a little bit objectionable about the side controller. I really prefer to roll left to the point where I find the arm position a little bit distracting on right rolls.

It doesn't seem--like the human engineering, it just doesn't seem natural to--the movement of my forearm and upper arm to roll right.

RUNS 545-547 Pilot 9, 3"RP, 7lb BO, 4lb/deg, AZP

Aircraft was controllable but I didn't think adequate performance was attainable. In fact, I think I'd have to go all the way to a 9. I did everything I thought I could and I did not have authority, I didn't believe to either control the stability of the nose or move it across the little pie-shape from extreme targets. So I'd have to go with an overall 9.

I'm saying that I had full right rudder and I not only had a lag in the motion but the nose of the aircraft was not going to track in time to even be able to stabilize on the far target. So for short movements, I was--for short movements say from the center target to the left target, I at least got the authority to get over to the point, it was lag, but then going from the far left to the far right, I had full rudder, was unable to even track the nose all the way over in a reasonable amount of time. Would have flown into the ground waiting for the nose to come over.

Forces seem to be a little bit too light. The actual displacement itself is good though. Directional control I guess would be the highlight of the objection in terms of the authority that I have. There seems to be too much of a lag in the response of the aircraft directionally, even with full rudder throw. In terms of this pilot's ability, I'd have to say it was about a 9.

RUNS 548-549 Pilot 9, 3"RP, 7lb BO, 8lb/deg, AZP

Aircraft was controllable. Adequate performance was attainable with a workload. I think that--I have to say that satisfactory performance needs improvement and I say that giving a rating of an overall 4. It seemed like the force gradient on the rudder pedal may have been nonlinear, but maybe if not nonlinear,

certainly at the far end of the deflection scale, the forces seemed to be high enough that I did not--had to compensate the input demonstrably more in order to move the nose laterally to certainly the extreme targets. So I think from the comment card, I guess the force issue a seeming nonlinearity at the high end, if not nonlinear, then certainly a little bit too high at the extremes and a little bit of instability once the pipper was on the target. So I guess the force and the little bit of jitter directional control around the immediate target would be items that special pilot techniques had to be adjusted for, have to give it an overall 4.

<u>RUNS 550-552</u> Pilot 9, 3"RP, 7lb BO, 4lb/deg, AZP

I'll tell you what I'm finding in overall generality that when you offset me, I'm aware a little more of the other two axes and ....

I'm finding that I'm a little more critical of your directional modes when I do that, maybe because I'm finding the other two axes that I wouldn't normally predominately use on that straight away offset. I think I'm blaming the combination of the three axes being a little more critical on the directional.

The aircraft is controllable, adequate performance is attainable. I think it is satisfactory without improvement. I think I'd go with an overall 3 because I was still aware of minimal compensation. I think it's the force. The displacement feels fine. Maybe just still a little bit light on the force. The directional control is a little jittery around the fine tuning. Either the force gradient was a little too light or not enough damping in the pedals. One of the two and it is such a fine little thing there, a fine correction, I can't really distinguish which one it would be. Overall 3.

<u>RUNS 553-555</u> Pilot 9, 3"RP, 7lb BO, 2lb/deg, AZP

The aircraft was controllable and I think adequate performance is attainable with a tolerable workload however, I think it needs improvement. I think that second run kind of threw me off but I think it came out consistently in the first and third run and I think I just lucked out on the second run.

So I would say that probably looks like moderately objectionable and I would say adequate performance requires considerable pilot compensation for an overall 5. Force gradient seems to be too light. Then with that, using the full throw, the directional control allows you to swing the nose to where you want it but with the light force without a feedback on a force gradient, then you get a self-induced lateral PIO about the target and if you don't hit it just right to where you can kind of pedal your way into damping out the nose motion, then you have a situation where you can only cover 2 of 4 or 3 of 4 targets. I think since it

was only one out of three, I think predominately what I saw was not enough tactical feedback in forces. Better go with an overall 5.

RUNS 556-559 Pilot 9, 3"RP, 1.5lb BO, 6lb/deg, AZP

I think I learned more on that one than I did the others.

Aircraft is controllable, adequate performance is attainable. I think I'm going to have to go in at satisfactory without improvement, NO. I think I'll have to give it an overall 4, with the idea that there was some moderate compensation required and it seemed to be if I didn't start right on nominal conditions, it seemed like there was perceived lag in response to an input. The force seemed fine and the placement seemed fine but maybe a little bit of a dashpot or too much damping or maybe even a deadband effect but a lag which could cause you to fall behind on the task of hitting all four targets. When that happened, it seemed like as I increased the force and displacement to try to acquire successive targets then became very difficult to go on. So that would have been--I would consider that moderate compensation and although it felt good, I think still maybe an overall 4.

RUNS 560-561 Pilot 9, 3"RP, 10lb BO, 6lb/deg, AZP

The aircraft is controllable, adequate performance is attainable with a tolerable workload and I think satisfactory without improvement. I would go to an overall 3, and it could easily become a 2 except the force gradient could have been just a little bit too heavy. I guess that sounds pretty inconsistent for me that I was aware of it. I was so aware that everything else seemed right for me, it seemed like just maybe a smidgen less on the force gradient and it would have been a 2. But since it seemed just a little bit high especially towards the portion of the run when I move between extreme targets, I became aware of a little bit of compensation stirred in and I think I'd have to give it a 3. Really that's kind of nitpicking.

RUNS 562-563 Pilot 9, 3"RP, 7lb BO, 6lb/deg, AZP

The aircraft is totally controllable, adequate performance is attainable with a tolerable pilot workload, however, we do need improvement. I think an overall 4 because of a perceived increased non-linearity or a steep force gradient on the rudder pedals, which became noticeable and required moderate compensation at the extremes of command in terms of the motion of the nose so it doesn't seem to show up again from target 1 to target 2, but then going from target 2 to target 3, there is a noticeable force gradient, high rudder forces, and it seems to slow down the process. I think maybe a little less gradient would have been a different story.

Overall the displacement again was good and directional control was good; it is just that I think with the increased force gradient fine tuning at the extremes on the target became a little bit higher loaded on the task so then therefore the increased technique is required. Overall 4.

RUNS 564-566 Pilot 8, .5"RP, 7lb BO, 25lb/g, WLT

I'm seeing no difference whether I put in -- I think if the rate changed with deflection of rudder pedals then the 2" versus 1/2" would really make a difference.

I think I like the shorter rudder pedal far better. I like it better but it's still -- I think the task is easier for me with a shorter rudder pedal deflection.

I think there's probably a happy medium between the two and the half inch.

I think I can rate that one. It's controllable. It has adequate performance, attainable with tolerable pilot work load. Yes. Is it satisfactory without improvement? Again, I think minimum pilot compensation. I give that a 3. I think the rudder pedal forces may be just a hair light. Just a little bit light. Not a whole lot. It's hard to tell. I think if they were a little bit heavier it would be all right. There's another thing. I can compensate for the throw by putting my rudder pedals farther out too than by having them in further.

With the two inch throw I can move my rudder pedals closer to my body and it feels okay. With the half inch throw I can move the rudder pedals further out and I am compensating for it. Now we have an airplane at the Test Wing where you have to do that because it takes one half the rudder pedal deflection to accomplish the same side step angle because the airplane has a 50% reduction in directional stability. The way you fly it is you roll the rudder pedals out further. If that means anything to you.

RUNS 567-568 Pilot 8, .5"RP, 7lb BO, 45lb/g, WLT

I like that one. I like the shorter rudder pedal throw with the pedals further out. But I think the rudder pedal forces are a little bit too heavy for me on this one.

It's controllable. It has adequate performance attainable with a tolerable pilot work load. True. Is it satisfactory without improvement? I give that a 4 because I think the rudder pedal forces are too high.

I'll tell you what I think about I like about the short rudder pedal throw is because the rates are so low that I need to go to a full rate to get the airplane over there. Now if the rates

were higher -- In other words, if I could go for say one inch of rudder pedal deflection and if the rates were higher, I think the rudder pedal displacement would make a difference.

But now if the rates were higher it would make a difference on the rudder pedal throw I think.

RUNS 569-570 Pilot 8, .5"RP, 7lb BO, 35lb/g, WLT

I like that one. That's nice. I can't tell whether the rudder pedal forces changed but I like that. That's controllable. Adequate performance is attainable with tolerable pilot work load. It's satisfactory without improvement. I give it a 3. Possibly the rudder pedals may be just a little heavy. But it's still okay. I like it. I'm ready to go to war.

RUNS 571-572 Pilot 8, .5"RP, 7lb BO, 15lb/g, WLT

I like that too except a little light on the rudder pedal forces it felt like.

It's controllable. It's adequate performance attainable with pilot work load. Yes. Is it satisfactory without improvement? I give it a 4 with rudder pedal forces too light. I like the shorter throw with the rudder pedals further out.

I think with the shorter rudder pedal throw it's better for this rate. If the rates were higher, maybe you'd be better with a longer throw.

RUNS 573-574 Pilot 8, .5"RP, 4lb BO, 25lb/g, WLT

Too light. A tendency to overshoot.

It's controllable. Adequate with a tolerable pilot work load. Is it satisfactory without improvement? I give it a 4 with too light on the rudder pedal forces. What it's doing is I'm overshooting. I'm having a tendency to bobble.

RUNS 575-577 Pilot 8, .5"RP, 10lb BO, 25lb/g, WLT

The forces feel ok, maybe I'm splitting hairs now, a little heavy but maybe not too heavy. It's ok, I like it.

I like that one. I like the short rudder pedal throw. It's the forces, I think they are just a little bit heavy, that's all I can say. Just nothing that you can give it a 3 to a 4, a 3, with rudder pedal throw and a 4 on the forces.

The forces are just a little bit heavy, I think. And I'm splitting hairs because they were a little too light before and now they feel just a little bit too heavy. And it's tough. . . 4.

Make it a 3. Make that one a 3. It's just tough to decide. It's good, I like it. So I guess it better be a 3.

<u>RUN 578</u> Pilot 8, .5"RP, 20lb BO, 25lb/g, WLT

OK, I can rate that one right away, give it a 4 with too heavy on the rudder pedal forces.

<u>RUNS 579-581</u> Pilot 10, 2"RP, 7lb BO, 4.0lb/deg, AZP

As far as comments, forces seem a little bit too light on that one, displacement is ok, so it's basically a little bit too sensitive. I think for the displacements the forces are too light. And it's hard to control it. Once you get it on the target, you got to really work to keep it on it. As far as a rating, it's controllable, I'd say adequate performance is attainable with a tolerable workload. I'd say I'd have to go with a 6 on that. Adequate performance requires extensive compensation - it's just too much bobbling around. You can do it, but it takes a lot of work.

<u>RUNS 582-584</u> Pilot 10, 2"RP, 7lb BO, 14lb/deg, AZP

I'm just trying to figure out now which force or deflection is objectionable to me, I know one of them is but I can't figure out which.

I think there's the displacement. Especially going from one side to the other. Forcing is ok.

It's just what appears to be the amount of displacement just pushing to get the nose over there. Well, let me follow up once here.

Forces seem ok, even with what I though was displacement, they seem ok.

I don't have near the tendency to overcontrol as I did earlier. You know, to ratchet back and forth around it. I can get to it pretty quick and hold it.

I'd give it all the way up to a 3, minimal pilot compensation required for desired performance. You still have to work at it a while, a little bit, but not very much. Well, I don't know, let me look at it a little while. Let's change it to a 4. I'd say it's more moderate than minimal compensation.

It's still - it's not something I'd like to live with. Which is what a 1, 2 or 3 is.

RUNS 585-587 Pilot 10, 2"RP, 7lb BO, 14lb/deg, AZP

Ok, on that one the forces seem a little bit too light. Too much tendency for overcontrolling. I'm sitting there fighting it back and forth trying to get it on the target.

I think it's as bad as the first one though so I'd go with a 6 again. Adequate performance requires an extensive pilot compensation. You can do it, but it sure takes a lot of work.

RUNS 588-592 Pilot 10, 2"RP, 7lb BO, 10lb/deg, AZP

I thought the forces were just about right. I still think this is a little bit too much deflection as far as displacement. I did notice it on the ones with the light forces but I think they kind of overrode it but the two stiffer ones I think it's too much displacement but this one wasn't bad, the harmony of the two of them. So I would give this one a 3 - I'd say minimal compensation required for desired performance. I didn't have too much trouble with that one at all.

I like that configuration. It still took a little bit but not much.

RUNS 593-595 Pilot 10, .5"RP, 7lb BO, 2.5lb/deg, AZP

Forces seem just about right. A couple with that deflection, the harmony is extremely good on that I think. I think it's satisfactory without improvement. And I'd give it a 2. Negligible deficiencies, it's not a 1 but it's not a 1 but it's pretty good.

RUNS 596-597 Pilot 10, .5"RP, 7lb BO, 4.5lb/deg, AZP

I didn't notice a whole lot of difference between the two of them. Maybe a tad bid lighter on the forces.

Compared to the last one, the one we just made a few seconds ago, I'd have to give it a 2 also. I rolled right in and put them on the targets all the time, didn't have any problem with it at all. I'd give it a 2.

RUNS 598-600 Pilot 10, .5"RP, 7lb BO, 5.4lb/deg, AZP

I like that, it was smooth. I'd give that one the same rating I gave the last one (2). Maybe a little bit lighter forces, it's hard to tell, it just seems so easy with that force and deflection combination.

RUNS 601-603 Pilot 10, .5"RP, 7lb BO, 1.5lb/deg, AZP

It's controllable but not much more. I'd have to go with about a 7, adequate performance not obtainable with maximum workload. It's controllable but control is hardly is just too light a force for this small deflection.

RUNS 604-606 Pilot 10, .5"RP, 7lb BO, 2.5lb/deg, AZP

Ok, on that one I'd have to go with a 4, desired performance requires moderate pilot compensation. Like the forces maybe still a little bit light. There's still a slight tendency to overcontrol. I'd say moderate compensation to make sure you don't. You can get desired performance.

RUN 607 Pilot 10, 3"RP, 7lb BO, 4lb/deg, AZP

Comments lost.

RUNS 608-609 Pilot 10, 3"RP, 7lb BO, 6lb/deg, AZP

I can rate that. I'd give it a 4, desired performance I could attain and it required moderate compensation. Not too bad but still took some so moderate, say about a 4 for it.

The problem is the throw I think. Judging how much deflection to put in. Forces are not the problem. Again I say, judging how much deflection to put in to get it.

RUNS 610-611 Pilot 10, 3"RP, 7lb BO, 2lb/deg, AZP

I will have to go with a 4 again on that. I can still get desired performance but, again, moderate compensation more moderate than minimal. Forces seemed a little bit lighter. Harmony seemed pretty good. Still had to work that a little bit though. I could give it a 3 but a 4 is reasonable. It's better than a 5.

I think I had the same problem of just how much deflection to give it. I thought the forces might be a little bit better on this one. The harmony overall was better than the last configuration. It still had about the same amount of trouble getting it.

RUNS 612-614 Pilot 10, 3"RP, 7lb BO, 4lb/deg, AZP

As far as comments, forces seem ok, displacements again, I don't the long displacement. Had a tendency to overshoot target. Put the cross on the target. Again, real hard to find the right amount of deflection to put it there. Force was not objectionable.

I'd have to go somewhere between a 4 and a 5. I could get desired performance but I'd say it took a little bit more than moderate compensation, I'd give it a 4, that's about as close as I can rate it.

RUNS 615-618 Pilot 10, 3"RP, 7lb BO, 8lb/deg, AZP

As far as rating that one, force seems a little bit heavier, no problem though. It's reasonable. Still don't care for that deflection, especially from the one side to the other. Seems like there's quite a bit of throw there. It's really hard to judge then how much to put in. But I can get desired performance with moderate compensation so I'd go with a 4 again. Hard to distinguish that one from the last one. I mean I could tell there was a difference but not very much.

RUNS 619-621 Pilot 10, 3"RP, 7lb BO, 2lb/deg, AZP

As far as rating that one, the forces were lighter but I could get the performance in and again, I'd say moderate compensation. Still having to work at it pretty hard. Let's go with 4 again.

RUNS 622-624 Pilot 10, 3"RP, 7lb BO, 6lb/deg, AZP

On that one, seems like the force was a little bit higher and it was a little bit harder to keep a pipper on the target for some reason or get it there and then keep it here, it had a tendency to want to go back and forth. I'd have to go with a 5 on that, I can't get adequate performance, hard to get desired, really keep it right on the middle of the target. I'd say adequate, I was working about the same workloads with considerable compensation.

RUNS 625-626 Pilot 10, 3"RP, 7lb BO, 10lb/deg, AZP

Ok, on that one there I didn't seem to have too much problem with it at all. I got desired performance really with minimal compensation so I'd have to go with a 3 on that one. A little bit of tendency going from one side to the other to try to guess what the deflection is going to be but I could get it there pretty quick and hold it so I'd have to go with a 3.

RUNS 627-628 Pilot 10, 3"RP, 7lb BO, 12lb/deg, AZP

Ok, on that one I'd have to go with a 3 again. It's minimal compensation that I can get desired performance without any problem. Other, than like say, minimal compensation. Still have a little bit of a problem with the deflection from the far one to the other one trying to guess it but the forces seem a lot easier to help judge it. I like the stiffness.

RUNS 629-631 Pilot 10, 3"RP, 7lb BO, 16lb/deg, AZP

Ok, I'd have to go with the 4 there. Desired performance requires moderate compensation. I definitely get the desired performance, can keep it right on it, the pipper right on the target but the force levels were such that it was kind of hard to judge how much to put on it. A little bit too stiff really. Had to work at it to judge the right amount of force.

RUNS 632-634 Pilot 10, 3"RP, 7lb BO, 14lb/deg, AZP

Again, I think the force was too heavy for the amount of deflection, it's going from again the far one to the far one. It was really hard to judge how much to force, it felt like I was almost standing on the rudder pedal to get it over there.

I say that has to be a 5, adequate performance required considerable compensation. I don't know that I could keep the pipper right on it. I'd say it's about a 5 on that one.

RUNS 635-637 Pilot 10, TBC, .025lb DB, .167lb/deg, AZP

I'd have to go with a 7. The airplane is controllable in that mode but you can't even get out of couldn't even hold it, get it on the target and hold it there with maximum workload, but controlability is not a question so I'd go with a 7.

I'd say go with the higher force. Give me a little bit higher force, let me try that.

RUNS 638-640 Pilot 10, TBC, .025lb DB, .25lb/deg, AZP

I don't know how to say it. It's not a PIO but that's what it is like. It has a tendency for an induced oscillation.

Ok, I'd have to go with a 7 again. You can't get it. No way I can get performance. I couldn't, once I started going one way, going toward the target, and then if I overshot it or something and when I tryed to come back, I just got an oscillation just back and forth. No you can stop it just taking your hand off of it so it's not uncontrollable but there's no way I can get even adequate performance, even get close to it. Definitely a 7.

RUNS 641-644 Pilot 10, TBC, .025lb DB, .5lb/deg, AZP

When I move the button to the left, the motion of my thumb moves the stick. I think that was what was causing the rolling, going to the left. It feels--it's just the natural action of my hand movement. I'm just going to climb up a little bit and fly straight level and see about this.

Each time I went to the left, I had a tendency--the airplane had a tendency to bank also. Going right, the hand doesn't move. But, to get the motion with the thumb, going left requires the hand to move.

I can answer the question "yes" to adequate performance obtainable with a tolerable pilot workload. So I would have to give it a 6. I could get close most of the time but it was extensive compensation. I really had to work at it.

RUNS 645-646 Pilot 10, TBC, .025lb DB, .75lb/deg, AZP

I can get adequate performance again, still not quite desired. I couldn't get it on the target and hold it there with extensive compensation so I would have to give it a 6. It still had a slight tendency to--the lateral oscillation--lateral PIO.

RUNS 647-649 Pilot 10, TBC, .025lb DB, 1.00lb/deg, AZP

I think we can get this one up to a 5. I can get adequate performance and I think it didn't seem to be quite the work load that the last one was. I'd go with extensive compensation. Still desired was not there. I'd rate it just a little bit higher with a 5. Still had the tendency to squeeze the stick going to the left and causing the roll.

RUNS 650-652 Pilot 10, TGSSC, .48in-lb DB, 4.8in-lb/deg, AZP

As far as any comment; I noticed the pulling up -- I'm not sure the harmony is right with this mode because on the pull up you have a tendency to twist the stick. I noticed a little bit of pull off there. The velocity vector and the pipper not being lined up. It didn't seem to be bad though but I think it's definitely something that needs to be looked at. I can get adequate performance with a tolerable work load without any problem. I have to say it's satisfactory without improvement. I'd have to give it a 3. I've been getting performance and a little bit of compensation but it didn't seem to be a whole lot. I would say minimal more than moderate compensation.

RUNS 653-655 Pilot 10, TGSSC, .48in-lb DB, 2.4in-lb/deg, AZP

The stick seemed a lot more sensitive then. Too much so I think. So I'd have to say their deficiencies do warrant improvement. I'd have to go with a 6. To get adequate performance. I could not get desired. Required extensive pilot compensation and there was a tendency for lateral PIO on some of them. I'd get an oscillation going and just couldn't keep it on the target at all.

RUNS 656-658 Pilot 10, TGSSC, .48in-lb DB, 3.6in-lb/deg, AZP

Still having a tendency to move the lateral lines as I pull up. Didn't seem quite as sensitive. Seemed like maybe there's a little bit too much displacement; more than I would like to see. I've got to turn the stick more than I care to. I could get desired performance then but I'd say it took moderate compensation. So a 4.

RUNS 659-660 Pilot 10, TGSSC, .48in-lb DB, 1.2in-lb/deg, AZP

Sensitivity, especially when I pulled the trigger, it tends to -- the motion in my hand tends to rotate the stick so it pulls it off the target.

Same comment as before. Still have the tendency to rotate the stick on the pull up. Also, pulling the trigger tends to pull the stick off due to the sensitivity. Also had a tendency for the lateral PIO. It's controllable. I guess I could give it as much as a 6. I could get adequate performance but with extensive work load. I didn't like the PIO tendency though; a little too sensitive.

RUNS 661-663 Pilot 10, TGSSC, .48in-lb DB, 4.8in-lb/deg, AZP

As far as comments; also I noticed going the opposite direction still have about the limits of the authority for displacement. I'm getting it over there. Going from one side to the other. I'd have to go with a 4. I could get desired performance with around moderate compensation; more than minimum but not any more than moderate. So a 4 is probably about right.

I think the authority was a problem there. It's easy to roll in on the first one and then when you had to go back to the other side it took a little bit to get there. I think the displacement is what's bothering me.

RUNS 664-666 Pilot 10, TGSSC, .48in-lb DB, 3.6in-lb/deg, AZP

Have to go with a 3 on that one. I can get desired performance in there with just a small amount of compensation. You gave me a pretty good configuration.

RUNS 667-668 Pilot 10, TGSSC, 4.8in-lb DB, 3.6in-lb/deg, AZP

For one thing, the deadband helps. I don't notice the tendency to pull off as I pull up. I can get desired performance with a small amount of work load. I give that one a 3. That seemed to be about the best configuration yet. Forces, displacements, deadband all seemed to melt together there really well.

RUNS 669-672 Pilot 10, TGSSC, 12in-lb DB, 3.6in-lb/deg, AZP

For one thing, I think the forces were too heavy. Somewhere between a 4 and a 5. Probably a 5. I could get somewhere between adequate and desired performance but it was a considerable amount of work load. So I'd go with a 5. The forces just were too heavy I think.

RUNS 673-675 Pilot 10, TGSSC, 2.4in-lb DB, 3.6in-lb/deg, AZP

The forces were pretty much okay. Very slight tendency for overcontrol. I could get desired performance though. So I'd say, with that little bit of overcontrol, call it moderate compensation; so a 4.

Seems to be quite a bit better.

When swinging it over there and holding it there, especially from one side to the other was the problem. And a little more trouble going right than left, I think.

RUNS 676-677 Pilot 10, TGSSC, 9.6in-lb DB, 3.6in-lb/deg, AZP

It seemed like the forces might have been a little bit heavier then. Still had the slight tendency for overcontrol. Very slight though. I'd have to go with a 4 again on that. I could get desired performance but again moderate compensation. Just a little bit more force than the last one.

RUN 678 Pilot 7, Conventional 2" Rudder Pedals, APP, 3 fps Turbulence

I can rate that if you want to. I don't think I'm going to learn anything. Give it a 2, Kevin. Maybe there's something better somewhere else but I don't know . . .

I'm real happy with the controller. It's a piece of cake. I can make a comment about the trim but I don't think that's necessarily required here. It would be nicer if we were trimmed out but easy; piece of cake.

Am I finding I have to hold much back?

A little bit but not bad. That's not a big problem. I like to -- especially with formation. I fly around nose heavy all the time anyway. Normally, in an approach mode, I try to trim it out. But it's not a big deal. I don't think its affecting my performance.

RUNS 679-680 Pilot 7, Conventional 2" Rudder Pedals, APP, 7 fps Turbulence

I can feel the turbulence problems now. This is delta sierra.

Landed short. That was tough. I've been kicked around before but I don't think I've ever seen anything that bad. I'm not even sure it's fair to rate it because wow. I've just never seen the nose moving around that much.

The axis giving me the turbulence problems is pitch. I give it a 6. Seems like the biggest problem was with the pitch. I wasn't using any rudders.

So it's conceivable -- I say I don't think I was using rudders. Maybe I was using it a little bit. Seems like deflections or random inputs to yaw were easily controllable. They're pretty realistic but the pitch problems would -- If a guy would have been in the back seat with me he would have been pretty frightened going down the glide path on that. The first tasks I did, I didn't notice the turbulence level until I was in the high gain, last 200 feet there. In this one you could, of course, feel it all the way out. You're quite nervous all the way down the flight path. Something I just said about the last configuration is that a turbulence input would do whatever it's going to do with the aircraft. It seemed like only after the input had

been made was I able to start correction back. So I wasn't able to prevent the whole impact of the turbulence. I wasn't able to stop the motion midway or something like that.

RUNS 681-682 Pilot 7, Conventional 2" Rudder Pedals, APP, 7 fps Turbulence

I'm having yaw problems there now.

My biggest problems are now yaw instead of pitch.

Give it a 5 and I would say the difference there is the fact that when I have pitch, which I don't feel totally in control of, I'm more concerned about stall and those kind of things and short, hard landings. It's more of a problem with me than it is if I'm a little bit less than desired yaw. So it's slightly better. As I said, the problems I'm now having are yaw and not pitch. I'm not saying pitch is good but it's not a prevelant problem this time. I think like on pitch this time, for example, I was keeping the AOA ± 1 bar length. Whereas before I was exceeding one bar length. Sometimes the bar was getting away from the velocity vector there. Tried a little bit of rudder it actually works the opposite. The nose is off to the left, push the right rudder and it seems to go further off to the left. Don't quite understand that one.

Some airplanes you can cheat and use rudder for small corrections like this. But that did not work on this one.

I didn't really notice any roll.

I haven't noticed the rolling components very much. Maybe think about that a little bit but it didn't seem that -- It seems a little artificial in that sense. You know, when you get gusts you normally think of -- It's like they have a pure gust inputs that either pitch or yaw and not the rolling tendency or something. A long lag between the rudder input and the nose of the aircraft.

RUNS 683-684 Pilot 7, 2"RP, 7lb BO, 300lb/g, WLT, APP, 7 fps Turbulence

I would give that a 5. The best I've evaluated yet -- the best is a 3 but I still don't think it's that good. It seems to me now my problem have gone back to I have a slightly greater problem with pitch than I do with yaw. The wings level turn I would say helps me a little bit but I'm not enamored with it. I'm not crazy about it. I didn't notice anything annoying like introducing roll. Forces, no problem. It seemed very natural the way the forces were. If I were going to change them though I would make them lighter.

RUNS 685-690 Pilot 7, 2"RP, 7lb BO, 100lb/g, WLT, APP, 12 kt. E Xwind

I'm having trouble now trying to break out the wings level turn from the other characteristics I see. I'm trying to decide how much advantage I feel like getting out of that.

I'm doing better.

I'm going to have to conclude I can do better without it.

This time my problems were all in the yaw and pitch was not really a problem. Of course, that makes sense if you're only talking about a crosswind here. Pitch control seemed to be pretty good. Overall I would say those were some pretty hairy corrections coming down the file there correcting for the cross winds. Still think that the crosswinds are constant. I would make that a 5 being moderately objectionable. As I said, I believe that I could do better without using the side force. it seems to me that the approach without it was easier to do and I was able to perform more accurately.

RUNS 691-694 Pilot 7, 2"RP, 7lb BO, 100lb/g, WLT, APP, 12 kt. E Xwind

I'm just flying a visual approach and using the crosshairs as information. It's a little like the A-7. On the A-7, if you fly the HUD glide path, you're going to "S" all the way down the glide path. If you fly basic instruments and cross check the HUD, then you'll fly a decent approach. (No rating given.)

RUNS 695-696 Pilot 7, Conventional 2" Rudder Pedals, APP, 5 fps Turbulence

I would say that feels pretty realistic. That would be an 18 to 20 knot wind in my mind.

Just in terms of the amount of turbulence that you get near the surface when the wind's blowing about that much.

With this configuration and different circumstances like higher turbulence level, I'd obviously give it a different rating.

I would give it a 3. Mildly unpleasant. The response you get is fairly satisfactory. I feel very satisfied about rates and all that; authority. I don't have too much to say about it though.

RUN 697 Pilot 7, Conventional 2" Rudder Pedals, APP, 20 kt. E Xwind

I don't believe that can change my rating at all.

RUNS 698-699 Pilot 7, Conventional 2" Rudder Pedals, APP, 30 kt. E Xwind

The way I was flying it I'm aiming for the spot and then I kick the crab out. So obviously I drift off the spot and I'm touching down kind of like center line. I haven't compensated for that.

I'm just kicking the crab out with the rudder only at the last minute.

I'm rudder only and then keeping the wings low with the stick.

I don't think you can really establish a wings low that quickly. On flight aircraft they do that. They fly down on the crab and they kick it out right at the last minute.

If the task includes the touchdown, I would say we have got a real serious problem here because right now it is quite a stress on the old airplane and all that good stuff. If the pilot feels like he's endangering his life -- that's me. Maybe somebody else would. I fly T-38 and you don't put a side load on that gear. It's just not stressed for it. Most gear aren't.

If I take the crab out then I start drifting.

I'm touching down in a drift and that's a side load. I'd give this a big -- I'm waffling between 8 and 9 here. I give it a big 9. In other words, I'm saying I don't think much of the technique here. With a 30 knot crosswind you're really going to put quite a strain on the aircraft.

I would use wing low unless I had an airplane that could land in a crab like a B-52 or C-5 or something like that.

RUN 700 Pilot 7, Conventional Rudder Pedals, APP, 30 kt. E Xwind

Not hacking it. This kind of combination here. I don't have enough aileron authority. Okay. This is kind of a combination here. This is all the aileron I can hold with my weak thumb. I'm aiming for between the two blocks. I had to use a combination of the two techniques as you can see there. If I'm using wing low I should be able to point the nose right down the runway. What I had to do is I put as much aileron as I could hold and then as much rudder as I could put in without causing the aircraft to be off to the left. On top of that, I had a little bit of crab there to the right. So it was comfortable. It's not the greatest thing in the world though flying without as much aileron authority as you would like to have; that you need. It was more comfortable than the last one. I'd give that an overall 6. I think I would feel comfortable landing an F-4 with that amount of crab in. I felt like it's not a big deal for the pilot to have that much crab in flying wing low there. His problem is the lack of aileron authority.

RUN 701 Pilot 7, Conventional Rudder Pedals, APP, 30 kt. E Xwind

I've still got a little bit of crab in it but this is much better. You can see I've got a little bit of, I'd say, 3 or 4° right wing low. The last time I was only able to get like a degree right wing low. What do I have? Maybe 5° of crab here. You wouldn't want to do this a long time. Really get your thumb tired here. I'm a little left of the center line here. I'm going to aim for the centerline. All right? I would say that was better but I'm going to still give it a 6. Same major problem. I've never flown an airplane where I was coming down the glide slope without enough aileron authority.

RUN 702 Pilot 7, Conventional Rudder Pedals, APP, 30 kt. W Xwind

If you want a rating I'd give that a 5. I don't know if you gave me any more increased aileron authority. I didn't feel like I had increased -- It was a little more comfortable because I wasn't fighting with my thumb. I was using the other side of my hand.

RUN 703 Pilot 7, Conventional Rudder Pedals, APP, 5 fps Turbulence, 20 kt. W Xwind

I can do that all day I think. I haven't been able to break out turbulence here. If you told me that was severe turbulence then I would say this thing really controls well. But if that's light turbulence then that would affect my rating.

I'd give that a 3. I think most guys wouldn't have any problem compensating for that. Good response. And maybe I would like a little lighter control forces. I have a problem though. I push harder on the stick than maybe is necessary for full deflection. But if you could look at a trace I would expect I was full deflection left aileron most of the time. I wonder if that's true.

In that case, I would object to the stick forces.

I don't feel uncomfortable with 20 knots of wind with a crab touchdown.

RUN 704 Pilot 7, 2"RP, 7lb BO, 6lb/deg, AZP, APP, 5 fps Turbulence, 20 kt. W Xwind

Pretty comfortable. I really like that because I don't have such a big problem with drift across the runway. I'm drifting from left to right on the runway and I don't like I'm -- So I don't start worrying about side loads on the gear and all of that. In fact, 20 knots feels so comfortable that I would guess that we could go higher than that.

I'm not sure if I had full pointing in. I think I lined up with the runway so I quit.

I would zoom up to a 3 here.

Rudder pedals felt comfortable. I'm used to kind of heavy rudder pedal forces. I felt those were very comfortable.

<u>RUN 705</u> Pilot 7, 2"RP, 7lb BO, 2lb/deg, AZP, APP, 5 fps
Turbulence, 20 kt. W Xwind

What I used there was the rudder pedals to put the crab in. That worked slick. You told me not to use the pedals till I get in the flare.

Insufficient authority. Cooper-Harper 8.

<u>RUNS 706-708</u> Pilot 8, 2"RP, 7lb BO, 6lb/deg, AZP, APP, 5 fps
Turbulence, 20 kt. Xwind

I think I can rate that task. The actual task of flying that thing down there is extremely difficult. I guess that's in the neighborhood of -- The pilot decision is usually controllable. Right now I don't feel it's controllable. I guess that's a 10. But, however, the ability to point the airplane is in the neighborhood of a 3.

It just feels like I'm on a piece of ice just sliding around. It just doesn't fly like an airplane. I don't have the cues I need. I can't tell when I'm lined up with the point and it's the simulator. I can hit the runway. Let me reevaluate that.

Okay. Pilot decisions. Is it controllable? Okay. I guess yes it's controllable. Is adequate performance attainable with a tolerable pilot work load? I think hitting that point you're going to hit it every -- if you're lucky. I think deficiencies require improvement. I would say a 7; adequate performance not obtainable with maximum probable pilot compensation. However, the pointing task, pointing the airplane, is a 3. I think the rudder pedal throw is too far. They're too large. I think it just boils down to the turbulence. Because when you fly an airplane down the runway you have a three dimensional picture. There's just more there. There's more cues there. You've got a two dimensional picture.

<u>RUN 709</u> Pilot 8, 2"RP, 7lb BO, 2lb/deg, AZP, APP, 5 fps
Turbulence, 20 kt. W Xwind

It's not controllable. If I have to hit the 75 foot thing I can't hit it, you know; not every time. But I can hit that runway somewhere on it. The airplane never did come all of the way around to the straight.

It never did line up with the runway. Let me try a couple practice runs. I need to pick up some other cues to get lined up with the runway other than one I'm used to using in an airplane.

RUN 710 Pilot 8, 2"RP, 7lb BO, 2lb/deg, AZP, APP, 3 fps Turbulence, 20 kt. E Xwind

The crab still isn't coming out.

RUNS 711-712 Pilot 8, 2"RP, 7lb BO, 2lb/deg, AZP, APP

I think that's a little better. The pointing's no problem.

RUNS 713-714 Pilot 12, 2"RP, 7lb BO, 300lb/g, WLT, APP

Exact comments lost. The run log indicates that the pilot felt that although the forces were high, the displacement and harmony were good and the wings level turn mode was nice. Cooper-Harper 4.

RUNS 715-717 Pilot 12, 2"RP, 7lb BO, 100 lb/g, WLT, APP

Exact comments lost. The run log shows that the pilot said the forces were good and that the task was easy in general. Cooper-Harper 2.

RUNS 718-719 Pilot 12, 2"RP, 7lb BO, 500 lb/g, WLT, APP

Exact comments lost. The run log indicates that the pilot gave a Cooper-Harper rating of 8.

RUN 720 Pilot 12, 2"RP, 7lb BO, 200lb/g, WLT, APP

Exact comments lost. Notes from the run log show that the pilot felt the configuration was satisfactory without improvement and gave it a Cooper-Harper 2.

RUNS 721-722 Pilot 12, 2"RP, 7lb BO, 100lb/g, WLT, APP

Exact comments lost. The run log indicates the pilot felt the configuration was satisfactory without improvement and again gave it a rating of 2.

RUN 723 Pilot 12, 2"RP, 4lb BO, 200lb/g, WLT, APP

Exact comments lost. The run log indicates that the pilot perceived a greater force requirement than previously and gave it a rating of 3.

RUN 724 Pilot 12, 2"RP, 20lb BO, 200lb/g, WLT, APP

Exact comments lost. As noted in the run log, the pilot rated the configuration a 5, the primary reason being the force required.

RUN 725 Pilot 12, 2"RP, 10lb BO, 200lb/g, WLT, APP

Exact comments lost. The notes from the run log show that the pilot commented about the forces being a little heavy and gave a pilot rating of 4.

RUNS 726-727 Pilot 12, 3"RP, 7lb BO, 100lb/g, WLT, APP

The comments I made the last run lessen the degree on that so that I think it's satisfactory without improvements for that approach. Maybe I'm left-eye minded or something but mildly unpleasant. It's not very hard.

OK, it's plenty adequate to do the job. Satisfactory without improvement, I'd say yes. Some mildly unpleasant deficiencies and the only one would have been a little bit much force in the beginning to get the nose cranked all the way around but other than that, I had to concentrate on using the rudders slightly. In other words, I didn't have to just think about using the rudders and things happened, I had to sensibly say, ok let's use the rudder and we'll put in that much. And I purposely didn't, I just said we're not going to use the bank at all this time, we're just going to use the rudders and see if we can't get there and I hit the stop on the left rudder initially to start.

3.

RUNS 728-729 Pilot 12, 3"RP, 7lb BO, 300lb/g, WLT, APP

Remember the comments I made the last time? Ditto. The same rating.

RUNS 730-731 Pilot 12, 3"RP, 7lb BO, 500lb/g, WLT, APP

It took me a couple of runs to realize that I didn't have to use my ailerons to control my drift across the runway but after that I sort of liked the idea of just using my feet.

OK, I'm all the way up to is it satisfactory without improvement. It's plenty adequate to do the task, however, we'll see if we can get it on the ground. But no, it's not satisfactory. I had to put too much force in both sides to get the airplane to do what I wanted to do. Also, it seemed to me that the response I got out of the airplane so the amount of pedal deflection was not as good or not as responsive as the time before. Whether that makes sense or not, I don't know. But the overall rating because of the force that I had to use just to get the airplane to do what I wanted to do is a 5.

RUNS 732-733 Pilot 12, 3"RP, 7lb BO, 200lb/g, WLT, APP

OK, I like that a lot better. I'd go back up to a 2 for that and that's for just the amount force necessary to get the nose to come around. It seemed to me to be more responsive although the rudder pedal deflection, the amount I deflected the rudder pedal seemed to be about the same but the force I had to use seemed to be much more consistent. I could concentrate more on where the airplane was going rather than how much force I had to use to get it to go there. It's up to a 2.

RUNS 734-735 Pilot 12, 3"RP, 7lb BO, 400lb/g, WLT, APP

You know the set before this one? The set before the set before this one, all those comments - ditto.

I'm down 4 or 5 because it's worse than the set previous to this one, I was again thinking about moving the rudders in order to do this instead of just going where I wanted to go. Can I get it to the runway, yes. Is it satisfactory without improvement, no it was making a moderate compensation, so I'd say 4.

RUNS 736-737 Pilot 12, 3"RP, 7lb BO, 200lb/g, WLT, APP, 5 fps Turbulence

A rating on that would be 2 for the reasons I said before. It's very well controllable. I think more of the problem is here than there. Satisfactory without improvement, yes. A negligible deficiency except that it was more, my reactions were that whereever I wanted to put the airplane, it went without a whole lot of objections.

RUN 738 Pilot 12, 3"RP, 7lb BO, 200 lb/g, WLT, APP 5 fps Turbulence, 25 kt. E Xwind

Boy is that over. Not bad.

That's a 2. For the same reasons as before.

RUNS 739-740 Pilot 12, .5"RP, 7lb BO, 125lb/g, WLT, APP
Note: only .1g authority

I just tried something a little bit different, I'll get to that in just a second. As far as things went, it's definitely controllable, both sides. Performance is adequate with very tolerable pilot workload. The difference I tried is it satisfactory without improvement, I'd say no and that's what you saw the difference between left and right. The first time it took, I felt an excessively long amount of time with my right foot on the rudder stop to get the nose turned around. I didn't get lined up til I was on very, very, very short final. So the second time I tried correcting with the wings and rolling over to see if I couldn't get lined up much quicker and use the rudders as a fine tuning

device compared to yesterday where I felt I could just put in a whole lot of rudder and the airplane would turn itself even with 25 knot crosswinds. Today, not so, the response I expected out of a half inch rudder travel I didn't get. I expected a lot more nose coming over so that's why I tried to bank the second time around. (no rating given)

<u>RUNS 741-742</u> Pilot 12, .5"RP, 7lb BO, 125lb/g, WLT, APP

OK, that was much better than the last time as far as the rudder pedal feel goes. It felt very precise. Definitely adequate to do the job. I think it's satisfactory without improvement the way it is. I'd give it a 2. I was actually able to fine tune much better than yesterday because I didn't have to move my feet so much I just put my heels on the ground and basically use the toes of my feet with a little bit of practice I could probably get even better.

<u>RUNS 743-744</u> Pilot 12, .5"RP, 7lb BO, 50lb/g, WLT, APP

It's adequately attainable, I can do the task again it may be me but I think with a little bit of practice, again, this could be used quite well fine tuning, the problem might come in if this is intended to be a fixed flight for the whole flight envelope. The pilot's legs might get stiff staying the same position all the time.

I'd rate it for a 2.

<u>RUNS 745-746</u> Pilot 12, .5"RP, 7lb BO, 25lb/g, WLT, APP

As far as the rudder pedals, I've got a rating for you. Again, as a fine tune mechanism it seemed a little bit slower pulling the nose around on the right hand approach with the crosswinds from the east but was still quite adequate, it did the job so I rate it at 2.

<u>RUNS 747-748</u> Pilot 12, .5"RP, 7lb BO, 75lb/g, WLT, APP

OK, on a rating for that, all the way up through is it satisfactory without improvements is yes, I could adequately do the job. Without improvements I'd say yes again. Pilot compensation is really not a factor for using the rudder pedals except that I have to remember once in a while to use only my feet, that's why the banking the last time. No big deal.

2. I don't know what you're changing but it doesn't seem to be effecting much of anything.

RUN 749 Pilot 12, .5"RP, 7lb BO, 175lb/g, WLT, APP

Alright, on that particular one, I don't think I need to see that one from the other side. It's adequate to do the job. Is it satisfactory without improvement, no. And the reason is, the force I had to use in the pedals, it was what I felt was an excessive amount to get the nose to swing over. It didn't lend itself to such a fine tune capacity as the last approach did. It didn't feel as bad as the ones yesterday because the leg didn't have as much throw, in other words, I didn't have to push my legs several inches and then change lever arms and so forth and so on but still it didn't lend itself to being a fine tuned thing so that's why the rating of 4.

RUNS 750-751 Pilot 12, .5"RP, 7lb BO, 225lb/g, WLT, APP

I'm ready to rate it anyway. What I think it is, I think you took a force grade out of the pedals. Whether you did or not, my rating is a 3. I felt it was a better instrument for fine tuning an approach but not as good as the ones we started with previously.

RUNS 752-753 Pilot 12, .5"RP, 7lb BO, 270lb/g, WLT, APP

Toward the end there it seemed like it was about the same force as the run previous to this one. However, at the beginning when I had to put in left full rudder to get the thing to start tracking over, it didn't seem that awful much of a force to put in. So I guess that was what you were referring to as breakdown being a little bit difficult.

I thought that you were just definitely setting a definite force that I would have to overcome if I wanted to put a small input in.

Okay, rating on that, up again to satisfactory, with that improvement I can get it down on the runway no problem. Deficiencies that warrant improvement, to me it seemed a little bit rougher to use again as a fine tune instrument, more pressure to get the nose to move over so I can rate it a 4 and that is based just again on the forces.

RUNS 754-755 Pilot 12, .5"RP, 7lb BO, 125lb/g, WLT, APP

Much better on those, satisfactory without improvement. I'd say yes, it lent itself much better to precise control down on final. Down close it got a little imprecise. I think that is more pilot than your simulation. A rating of 2 for that.

RUN 756 Pilot 12, .5"RP, 4lb BO, 125lb/g, WLT, APP

I'd say a 2 for that one also for the same reason as before. Very, very precise on final. It responded really well. I don't know whether I'm just quicker off the motion cues or not, but when I put in full left rudder the nose came right around that time.

Again, for your test, I am just trying to use my feet solely, but on that last one, I doubt seriously I could have gotten it on track any quicker by using the ailerons either. It was a real debate, I probably could have if I'd really tried. This I feel is a little more precise than that you don't have to get so many variables into the picture.

RUN 757 Pilot 12, .5"RP, 20lb BO, 125lb/g, WLT, APP

Okay, on that one I really don't think I have to see it from the other side either. A rating on that I'd go back down to a 4. The reason is the force I had to use to get the response was better than the previous rating of 4. In other words, the nose came around much quicker, but again the pressures I had to use took some of the feel out of the pedals. In other words, you could feel better with the setting of whatever it was last time. This time not so much as like grabbing a pull really hard and you can't feel in your palm when you have something really hard grasped in your hand.

RUN 758 Pilot 12, .5"RP, 10lb BO, 125lb/g, WLT, APP

On that one I can go back up to a 3. Again, the pressure was less. I could use it more as a precise alignment tool.

RUN 759 Pilot 12, .5"RP, 38.5lb BO, 125lb/g, WLT, APP

Bad news on that one. That was way too tough. Put that down as low as a 5 because of the amount of pressure. I tried a full cross check that time between airspeed altitude and all that kind of stuff when I found myself consciously thinking about the rudder pedals. How much force I was going to have to use versus just aiming for a point and sort of thinking the aircraft into the runway.

So I want to go with a 5.

RUNS 760-762 Pilot 13, 2"RP, 7lb BO, 700 lb/g, WLT, APP

Is it controllable - yes. Is adequate performance attainable for tolerable pilot workload - I would say no.

I'd say number 8 there - considerable pilot compensation is required for control. Unless I caught that very, very quickly, I was going to be in and off the left end of the runway. And no matter how much I pushed on it, it wasn't getting me over there in what I consider to be reasonable amount of time.

You say on my displacement is a maximum 2 inches to the stop. Okay. I went up against the stops and the force on there seemed to be adequate, but it just did not get me to where I wanted to go.

RUNS 763-765 Pilot 13, 2"RP, 7lb BO, 100lb/g, WLT, APP

I think we can move up now. It's adequate performance obtainable with a tolerable pilot workload. I would say it is satisfactory without improvement. I'd give it a number 3.

I would say the forces are just a little bit light compared to the stick responses. They seem to be sensitive enough and have enough authority. Do I have any turbulence now?

It is fairly light.

RUNS 766-767 Pilot 13, 2"RP, 7lb BO, 300lb/g, WLT, APP

I basically found the forces to be just a little bit high. The displacements were okay and the harmony is fair.

I give it an overall 3.

RUNS 768-769 Pilot 13, 2"RP, 7lb BO, 500lb/g, WLT, APP

Now I assume what I am trying to achieve here with these rudders is to be able to get myself lined up without use of any banking as much as possible, and if I need bank then add it.

I would say that is a 4. The forces are pretty excessive and required somewhat a banking in order to achieve the task. Control authority seemed to be lacking in that I needed more than just a rudder to get myself around. I'm just looking at your list here to see if there is anything else I can add.

Sensitivity seemed to be moderate, but it required a good deal of force in order to achieve which you wanted to do.

RUNS 770-774 Pilot 13, 2"RP, 7lb BO, 200lb/g, WLT, APP

It just seems so much easier to control when the winds are out of the east than the one we did prior to the last two. This one seems pretty hard to control as far as trying to land where I want to land that is.

My problem is basically a lateral one.

Maybe I just like to look out the left side of the canopy. I don't know.

. . . . . sitting in the left seat and when I crab to the right then I was looking out more my window than across the canopy or across the cockpit. That could be a factor. It feels more comfortable.

The other thing is for the right cross wind when the wind comes from the right to the left, the wind initially helps you correct that slight amount of error there is in lining up on the patch. Now when you're going in the other direction it doesn't do that. It actually hurts you more.

That could be a factor, too.

That felt a little better.

I think I'll rate it. I'd say it is a 3 also and it appears that the stick forces or the rudder forces are what I consider to be adequate and pretty well harmonious with the inputs you need for the stick. There was certainly enough control authority and sensitivity seems to be about right.

I tend to not want to make any comments about differences between left and right crosswinds because of my bias.

<u>RUNS 775-776</u> Pilot 13, 2"RP, 4lb BO, 200lb/g, WLT, APP

I'd call that a 2. Placement seems adequate. Forces are adequate. I think as far as the breakout force, it's just a tad bit too much there for me to initially get it going. Authority seemed to be pretty good and once you were able to break it, sensitivity was fine.

<u>RUNS 777-778</u> Pilot 13, 2"RP, 10lb BO, 200lb/g, WLT, APP

Sometimes there seems to be such a fine difference in what you're doing and not having any experience with this is kind of hard for me to get my legs calibrated.

I would call that a 1. I didn't see any problem with the breakout forces or anything. It seemed to me to be adequate as far as displacement and harmony and sensitivity and authority. I didn't have any problems whatsoever. I haven't really seen much effect as far as looking down here at this chart. It's an effective turbulence on the aircraft response, it seems pretty good. I don't have any special piloting technique order required, just hand-eye coordination. I didn't see any limitations as far as the simulator on my ratings.

<u>RUNS 779-780</u> Pilot 14, .5"RP, 10lb BO, 125lb/g, WLT, APP

It was controllable, adequate performance obtainable at a tolerable workload. Satisfactory without improvement, yes. Characteristics, I would say it's fair with some unpleasant deficiencies

with minimal compensation required, so I'd give it a 3. As far as your comment card, I've done the rating, No. 2 control feel characteristics, forces, displacements and harmony. The forces are fine; displacements especially with directional control--the rudders. I'd like to have it kind of a higher gain, a little tighter. It seems like a couple of times I've almost been banging off of the stop.

I'd like to see less displacement.

The overall harmony of the control of the airplane seems pretty good really. It seems all right for this task that we're doing except for the comments already made about the rudder control authority. It seems okay. I guess the authority of the yaw is fixed anyway as far as the maximum authority. It was maxing that out several times, so whatever it is, it is. If I had my druthers, I would have more authority. Inputs, roll control, that seems good. It is very responsive in the roll axis and the pitch axis, directional control is good. I am still getting used to that but it's very responsive to the rudder inputs. The uncoupled mode control of pointing seems to work pretty good. I am working at not using the roll axis at all. I am using it some, but trying to minimize that and use only the directional control even if I end up with some bank; I am trying to just leave it there, just use the rudders. It seems controllable. It affects the turbulence. I don't think it had any effects or special piloting techniques required.

Summary comments. The primary reason for the rating of 3 is because it's the first rating. The unpleasant deficiencies were maximizing the rudder travel and the rudder authority. It seems like I was doing that quite often, so that required some compensation. Perhaps in time I'll learn to need it a little bit and that will go away. What affect did simulation limitations have on your ratings? At this point, it is hard to say.

RUNS 781-783 Pilot 14, .5"RP, 7lb BO, 225lb/g, WLT, APP

Going up the decision tree again, it was controllable with a tolerable workload and it's satisfactory without improvement. I think it's still fair with requiring minimal compensation for the desired performance. There again, mainly, in kind of determining the amount of displacement of whatever is required to get the crab n and have it early enough so we're really flying straight down the runway. I still find myself kind of on and off the stops of the rudder pedals where I think I should be able to do it without banging off the stops every time. I think the learning process will improve that. Cooper-Harper 3.

RUNS 784-785 Pilot 14, .5"RP, 7lb BO, 75lb/g, WLT, APP

For Cooper-Harper, it was controllable with a tolerable pilot workload, satisfactory without improvement, yes. I liked it

better than the previous runs but I'd still rate it as a 3, merely because it still requires minimum pilot compensation. I think I preferred it because the breakout force--the overall force requirements seemed down. I think it was better although I'd still rate it as a 3.

RUNS 786-787 Pilot 14, .5"RP, 7lb BO, 25lb/g, WLT, APP

It was controllable with a tolerable pilot workload, satisfactory without improvement. Here I might say "no". Deficiencies warrant improvement, minor but with perhaps moderate compensation. I'd give it a 4 because it's gone too far as far as loosening up the force required, it's just too loose. I don't feel I can make small enough corrections handling. Sometimes after landing, I've tried to apply the brakes as one might wish to do when he's landing and that's just too loose to accomplish the task very reasonably.

RUNS 788-789 Pilot 14, .5"RP, 7lb BO, 175lb/g, WLT, APP

That was better. It was definitely controllable with a tolerable workload and satisfactory. Puts it in the top 3. Again, I think I'll give it a 3 but it's probably the highest 3 I've given it because I still feel that there is minimal conscious compensation on my part which would probably go away in time.

You'll see that before I was hitting like the edges of that strip but I had no trouble with those landing close to the center of the little patch. I might be learning but I found it easier to control whatever that configuration was.

Of the ones so far, I did like that at the best so I would say would be a 3+ or whatever you want to say, but a good 3 almost a 2 but not quite.

RUNS 790-791 Pilot 14, .5"RP, 7lb BO, 50lb/g, WLT, APP

I found it was controllable with a tolerable workload, satisfactory without improvement. I would say "no", that the deficiencies warrant improvement. Moderate pilot compensation was required therefore, I'd give it a 4. The light forces and displacement is, again it seemed like I was in a bang, bang system. Whatever I wanted to put any input in I would just go all the way to the stop bang, bang, and back to the left so I didn't feel like I had real good control; that's what I didn't like and that's why I'd give it a 4.

RUNS 792-793 Pilot 14, .5"RP, 7lb BO, 125lb/g, WLT, APP

It was controllable, adequate performance with a tolerable workload, satisfactory without improvements. I would say "yes". This one I might give a 2 to. It was good, negligible deficiencies where the compensation wasn't really a factor. Some of that

might be my learning curve but I did like the overall breakout force and I wasn't banging off the stops with that. I hit the control I wanted without hitting the stop and it felt a little more responsive to me. I'd give that one a 2.

RUNS 794-795 Pilot 14, .5"RP, 7lb BO, 270lb/g, WLT, APP

The rating it was probably controllable, adequate performance with a tolerable workload, yes, but is not satisfactory without improvement. I'd call it minor but annoying requiring moderate compensation, I'd give it a 4 and the forces involved to get the adequate response are just too heavy and what it really does; it destroys the harmony between the other axes, the forces are just too heavy.

RUNS 796-797 Pilot 12, TGSSC, .48in-lb DB, 120in-lb/g, WLT, APP

All the way up through satisfactory without improvement. Minor but annoying deficiencies, no and the minor deficiency is that there seems to be no graduation of, there was but not to a great degree when I would put in a right yaw or right turn, a right twist with the stick, I didn't get anything for awhile and all of a sudden I got what I wanted real fast and that allowed for no rate so it tended to make for just say, okay fine use it as an on-off switch, open-shut, open-shut. For that reason, a 4. It's sort of like the old fighter planes used to control air speed on final by turning the engine on and off. Either you had everything or you had nothing.

RUNS 798-800 Pilot 12, TGSSC, .48in-lb DB, 60in-lb/g, WLT, APP

Exact comments lost. The notes from the run log indicate the pilot felt the configuration was not satisfactory without improvement and gave it a pilot rating of 5.

RUNS 801-802 Pilot 12, TGSSC, .48in-lb DB, 30in-lb/g, WLT, APP

Exact comments lost. The run log shows that the pilot said that the configuration was satisfactory without improvement, and gave a rating of 3.

RUNS 803-804 Pilot 12, TGSSC, .48in-lb DB, 90in-lb/g, WLT, APP

Exact comments lost. Notes from the run log show that the pilot felt the forces were too high. Cooper-Harper 5.

RUNS 805-806 Pilot 12, TGSSC, .48in-lb DB, 40in-lb/g, WLT, APP

Exact comments lost. Notes from the run log show that the pilot felt the configuration was satisfactory without improvement. Cooper-Harper 2.

RUNS 807-808 Pilot 12, TGSSC, 2.40in-lb DB, 40in-lb/g, WLT, APP

Exact comments lost. Operator's notes from the run log indicate that the pilot said that he was using the twist as an on/off controller and that the response was too abrupt. Cooper-Harper 4.

RUNS 809-810 Pilot 12, TGSSC, 9.6in-lb DB, 40in-lb/g, WLT, APP

I'm using the wings level turn almost exclusively. I tried to blend a little bank in, rudder in at the same time but, as far as directional control, the wings level turn almost all the way down.

The rating on that particular one was a 4 again for the on-off tendency--to use the thing when I'd push it just a little to get some reaction out of it--no. By then I'd have to put in a bigger reaction so the tendency is to firewall it and I have again very little touch-type feel with the stick, very little finesse with it so I tend to use it as an on-off switch.

RUN 811 Pilot 12, TGSSC, 14.4in-lb DB, 40in-lb/g, WLT, APP

Better than the last time all the way up to a 3. It's a little bit imprecise but, again, this time I had more of a control with it so once I say the nose moving, I would lighten up. When it did move far enough, then I'd go ahead and get on it but I knew I could lighten up on the stick and get a feel back for it so I could fly with a looser grip, much more relaxed.

RUNS 812-813 Pilot 12, TGSSC, 2.40in-lb DB, 40in-lb/g, WLT, APP

That one all the way up to a 3 again. Once I realized I could get the control I wanted out of it, I backed off on the stick pressure and could feel a lot more. One comment about all of these is that the tendency for me to get what I want out of the airplane is to make a specific two axes or two direction input either I want to go sideways or I want to go up or down, there is no tendency to do a blended thing like up at a 45° thing. I have tried it once or twice and both times I've had to stop all the inputs because the nose was hunting around--and go back to, well I would move it in one direction either left or right or up and down, very mechanical.

RUNS 814-815 Pilot 12, TBC, .05lb DB, 25lb/g, WLT, APP

Adequate performance obtainable. I could land the airplane. Satisfactory without improvement, I'd say "no" and the minor but annoying deficiency was that I was basically fighting myself on the controller. In other words, when I'd press left or right, again I would have to grab the controller and on the warmup runs, I noticed this particularly, if I had any kind of bank at all--if I had to turn into the bank, for instance, if I had a right bank and I wanted to bring the nose around and I remember all of a

sudden had this capability if I pushed right, it had a tendency to deepen up the right bank as I was pushing into my own hand, so that plus gripping the stick again whenever I had to move it, I had to grip it just enough so that it made delicate control a little bit hard, that's a 4.

RUNS 816-817 Pilot 12, TBC, .05lb DB, 8.33lb/g, WLT, APP

Well, I'm hitting it but not real well.

I'm just talking touching the target. As far as where I'm hitting on the runway, I'm getting pretty consistent.

On that one, is it satisfactory without improvement category. I'm up to a 3 on that. I don't know what you changed if you changed anything but on both those runs, it seems much more manageable without a whole lot of pressure. Maybe it's just because we did the calibration again.

It seemed much more manageable. Again, a little bit on the grip but I'd say it's a gripping problem but I'd say it's no worse than the twist grip yesterday.

RUNS 818-819 Pilot 12, TBC, .05lb DB, 5lb/g, WLT, APP

OK, on those two, I'm still trying to play with the vertical translation a little bit but as far as the wings level turn business, I like that one quite a bit. That's a 2 at least. Negligible deficiencies when I touched it, it moved and I didn't have to clamp my hand around the stick at all. If I had to use the bank I could use it and the wings level turn button also without affecting any of the bank characteristics at all.

RUNS 820-822 Pilot 12, TBC, .05lb DB, 4.17lb/g, WLT, APP

OK, as far as the rudder wings level turn button is concerned, again it felt like a 2 to be for the same reasons as I stated before, both sides very easily controllable. The only difference in technique I was trying between the last two was that this last one I tried tapping the vertical translation again and the one before that I tried a T-38 type approach where you aim short and then hold it off and try and touch down. So, I was short this last one and the one before that was about the same place as always. That's part of the reason for the retake and still trying to get used to this HUD again but as far as the rudder controller, the wings level turn thing is a 2.

RUNS 823-824 Pilot 12, TBC, .05lb DB, 12.5lb/g, WLT, APP

My control strategy is to tap the outer edge. I'll tap the outer edge on either side and stay away from the middle. That's where I get the most precise control. As far as the button position is

concerned, it's fine with me as long as I don't have to grab the stick with my hand too hard, as long as the touch is light, no problem with location.

There really is no moderation, it's basically an on/off switch but on the last couple of runs were a very fine on/off switch. It seemed like I didn't have any qualms with it really whatsoever because if I wanted to get a whole large input in, I'd just leave my finger on it for quite a bit and if I pressed harder it would speed it up so that didn't bother me.

Yes, that was still a 2 for the same reasons. I can't detect much of a difference at all.

RUNS 825-826 Pilot 12, TBC, .05lb DB, 25lb/g, WLT, APP

OK, on that one I'd say it's a definite 4 for the reason that it has minor but annoying, in fact it's almost a 5 but I'll stick with a 4, minor but annoying deficiencies. Remember the comments on the first run that when I had to use the turn, especially for a wings level turn controller, especially for a large amount of turn, I had to grab the stick quite heavily. Now, the rate was a little bit slower also. It seemed I pushed hard to get the maximum, to get the nose to move the way I thought it should move. For that reason, it's a 4.

RUNS 827-828 Pilot 12, TBC, .05lb DB, 3.13lb/g, WLT, APP

I'll take a 3 on that one. It's not as good as good, relative good as the earlier ones where I gave a 2 and the reason is when I finally did push on the turn controller, it moved quite nicely. It seemed like no reaction for a while and all of a sudden, wow, and then for that reason once it started moving it lent itself to precise but again, I had to get on it so I'd give it a 3. It's better than the last set.

Remember what you told me about deadband yesterday?

Well, it seemed, I don't know what you changed but it seemed like I have to push the switch a little bit more before I get a response out of the airplane but the response I do get is very nice and it's very good so I guess you could say it's more an on/off switch. Before it was an on/off switch but not as bad as this. And the response I do get when I get one is of a magnitude such that I don't have to get on and push and grab the stick real hard.

RUNS 829-831 Pilot 12, TBC, .05lb DB, 2.50lb/g, WLT, APP

OK, as far as the approach is concerned on both sides, the control was very adequate for the job. I could get the airplane on the ground, no trouble. But down near the ground, satisfactory without improvement, I'd give it a 3. Some mildly

unpleasant deficiencies and the mildly unpleasant deficiencies, as I got down closer and I wanted to make very fine adjustments to the direction, it seems like from the east the winds are shifting as you're coming down through the flare even. That's why I'm setting up this left drift and I'm just trying to use this controller to counteract it to get it to go straight and with this particular set up those were a little bit hard to do and I was grabbing the throttle and that's why control was imprecise to a degree. Also, I solved the touchdown problem. It's more me not the simulators because I've been forgetting to raise my eyes toward the end of the runway and it's very difficult to land when you're looking straight down. It's easier when you get a height reference from far away. So that's why things have gotten a little bit better toward the later half here.

I've sort of given up playing with the vertical translation for the moment because the second that nose comes up, I have no idea where that spot is. I base my guess on a banana maneuver and my aim point is about 3 sets of lights down from the bottom edge of the square.

I think it'd be more teaching me to get all my planning out of the way first and then take the flare as a normal flare. It's not bad to use at all.

<u>RUNS 832-833</u> Pilot 12, TBC, .25lb DB, 5lb/g, WLT, APP

On that particular one, I give it a 3 for the same reason as before. It's still that when I get down real close, it's not real precise but it's plenty adequate to do the job and it would be alright for everyday use. On that one I tried using the vertical translation. I think it might be a better idea once I get my altitude set down low. We'll see what happens.

It'd be useful as a very fine tune device down low. Just now getting around to that.

<u>RUNS 834-835</u> Pilot 12, TBC, .75lb DB, 5lb/g, WLT, APP

OK, that particular one goes down to a 4. And the reason is, especially on the right approach where I was working my thumb in toward my index finger close when I wanted to make a right turn with a right hand I had to get a pretty good amount of pressure going before the nose would start coming over. That's why I did the left and made a big haul over to the right before I got the response I wanted. I had a pretty good grip on the stick and from there on it became a little more imprecise to control the aircraft. As far as the vertical translation is concerned, when you get down close in winds I've been noticing my attention is directed outside of the cockpit and on basically only one controller at a time. Now, maybe this is just that I can't walk and chew gum at the same time or, I don't know, it's just that I tend to just pull the power and forget it and then use my right hand to get me down. That's the way I've been flying for 5 or 6 years so it may take a while to unlearn that.

In general, I tend to ignore the vertical translation.

RUNS 836-837 Pilot 12, TBC, .0251b DB, 51b/g, WLT, APP

The roll excursion in the middle was me trying the difference between the two. In order to get the nose over to correct for what was going without the controller, that's what I would have to do. And immediately after I tried the controller itself and I prefer that a lot better for a fine tuned thing and still I'd go with a roll excursion like that if I had a major correction to make. It's much more convenient to use the controllers. I tried that just for grins.

OK, that one was up to a 2. As I said before, a fine tune device that works real well. I got on it early and I started just tapping the switch. More like stabbed. In other words, if you just sit there and tap your finger on the table, well that is essentially what I was doing with my thumb on, especailly left yaw commands, turn command whatever it was, just stabbing the button, moving the thing around fine tuning where the flight path was going to go.

RUNS 838-839 Pilot 13, TGSSC, .48in-lb DB, 240in-lb/g, WLT, APP

Well, as far as response of the controls, I would go ahead and rate that a 3 with the additional comment that I don't care for the isometric exercise.

Force seems to be a little bit too hard but it's really hard to tell when you don't get any movement. The twist displacement is kind of innate, you hardly feel any of that. There seems to be enough authority to make the correct corrections.

RUNS 840-842 Pilot 13, TGSSC, .48in-lb DB, 120in-lb/g, WLT, APP

Exact comments lost. Notes from the run log indicate the pilot felt the sensitivity was good and the harmony was right. He gave a Cooper-Harper rating of 3.

RUNS 843-846 Pilot 13, TGSSC, .48in-lb DB, 60in-lb/g, WLT, APP

I'd call that one a 3 also. The sensitivity, the controls are just a little bit too light. It doesn't take much for you to get full displacement on that. There is enough authority if you just watch what you're doing and realize how sensitive it is. Of all the ones you've shown me that's the most sensitive. I still like that twisting on the throttle, I think that would be pretty handy.

It's kind of a natural feel that if you bring the throttle back and the flare and also maybe coordinate that with a twist you can really get some nice landings out of it.

RUNS 847-849 Pilot 13, TGSSC, .48in-lb DB, 180in-lb/g, WLT, APP

I'd give that one a 3. I think the sensitivity of the controls were a little bit stiff compared to--as far as the harmony with the other controls. There seems to be enough authority. It is just that you seem to have to honk on that thing to get it to move compared to the rest of the axes of motion in that stick.

I think it would take a while before one would consider twisting the stick to be a natural act.

Other than a matter of getting used to the controller stick, there is nothing that would be--I wouldn't say it is affecting the ability of one wanting to buy the airplane or whatever.

RUNS 850-851 Pilot 13, TGSSC, .48in-lb DB, 240in-lb/g, WLT, APP

It is entirely controllable, it would be just like going between two different airplanes, like T-38 or a fighter or something and go B52, you just have to get used how much input is going to do what for you.

I'd say between all the modes that you've shown me today, we are kind of splitting hairs as to its ability to do the job, it's definitely in there, it's just a matter of how much you want to twist on the thing with your hand.

I give that one a 4. The sensitivity--it takes too much of a twist to get the adequate response and as a result if you don't catch it quick enough, you are going to be behind the power curve. I'd say it required moderate compensation. I had to use my wings level turn to try to get back to where I wanted to go. As far as the harmony with the rest of the controls it's much too difficult to move in compared to the rest.

RUNS 852-853 Pilot 13, TGSSC, .48in-lb DB, 40in-lb/g, WLT, APP

I'd give that a 3. Sensitivity is too slight as far as the amount of force necessary. As a result you intend to overcontrol it. I would want just a little bit less sensitivity in it as far as the harmony with the other controls.

I'm kind of wavering now. Why don't we call that one a 4.

It does have some annoying deficiencies.

But then you look at this and you say well, what's the difference between minimal pilot compensation and moderate pilot compensation?

Whether it warrants improvement or not.

The one before this I said was real hard to control as far as the forces. I gave that a 4 didn't I.

RUNS 854-855 Pilot 13, TGSSC, 4.8in-lb DB, 120in-lb/g, WLT, APP

Okay, controllable. Tolerable workload, yes. Now I have to think a second about this one. I'd say it is satisfactory without improvement. It seems just a tad bit--if I say too hard to move it compared to the other controls, I don't know whether that should knock it down to a 4 or not. As far as the harmony with the rest of the controls, I didn't notice any difference whatsoever between when we were messing around without the dead area there that you are talking about. I'd say as far as the harmony is concerned it is a little bit more difficult to activate that control than the rest. Insofar whether that is a discrepancy that needs improvement, in that case I'd call it a 4.

Well, we can always seek improvement, anything that comes along. I'd call that one a 4.

Basically because it's too stiff.

RUNS 856-857 Pilot 13, TGSSC, 4.8in-lb DB, 60in-lb/g, WLT, APP

That one seems about right as far as sensitivity compared to the rest of the controls. I was able to handle it. I had a little tendency to overcontrol, but I think that's more me than the machine. I'd rate that a 3.

I can't tell any difference as far as the dead area.

RUNS 858-859 Pilot 13, TGSSC, 9.6in-lb DB, 60in-lb/g, WLT, APP

I'd give that a 4. It is much stiffer than it needs to be. Sensitivity takes just a bit too much compared to the rest of the force inputs. Again I didn't notice any real difference in the dead area.

RUNS 860-861 Pilot 12, 2"RP, 7lb BO, 8.95lb/deg, LTR, APP

I can rate it but I'm going to try another technique I'm going to explain in a minute. It may come out a little bit different, but as far as these two are concerned, adequate performance is---I can land the airplane, yes. Is it satisfactory without improvement, I'd say no, minor annoying deficiencies is that I was holding what I felt was like a very large footful of rudder. Both sides in order to keep this kind of an airplane lined up with the runway. It felt a rudder that I would use sort of like for a C-141 go-around with one of the outboard engines inoperative. In other words, I was really standing ..... I got to notice it. It was a heavy force required to get the airplane to quit drifting once I had the flight path lined up down the runway. That's a 4.

Up until now, what I've been doing is I just line up the aircraft flight path along the runway, on the block. As it wants to drift left, I'll just keep feeding in right rudder for instance to stop so it doesn't drift anymore. Then use it that way. What a lot of guys will do on final is they'll set up with a crab there and I'm going to try to set up with a crab and then take it out and see if I don't get my feet crossed.

RUNS 862-863 Pilot 12, 2"RP, 7lb BO, 2.98lb/deg, LTR, APP

I am using the vertical translation.

That's what enabled me to put it on the block that last time. I just pushed down and it hit.

You say hit the block so I'm doing with what I've got to do that. I could rate your rudder pedals for you. I'd go down to a 5 on that one. Moderately objectionable deficiencies. This time is the exact opposite comment from the previous set where those were too heavy, these were too mushy. I had no positive feel to the rudder pedals whatsoever, as to what force was what. An additional comment on the crab when I set up an initial crab, sure enough, when I wanted the nose to point straight down the runway, my initial tendency was to use rudder instead of left rudder, so I said Oh, No, that's wrong when I saw the airplane starting to drift across the runway and then have to take out the bank as I fed in left rudder.

I am basically using it as a pointing mode in that respect.

I just wanted to try that on a couple of runs to see what would happen and sure enough I had the wrong rudder pedal.

RUNS 864-865 Pilot 12, 2"RP, 7lb BO, 5.97lb/deg, LTR, APP

Satisfactory all the way up through satisfactory without improvement. I could get it there, no problem. There are some mildly

unpleasant deficiencies, a 3. Still just a tad mushy, but a tad is very vague. It's better than the last run but not as bad as the first runs we went on. It could stand, I think, to be just a little stiffer then I could just set my heel on the floor basically and run it full forward. Also, this is a fighter-type aircraft, I'm having to slide my foot across the floor quite a bit in order to get full benefit out of the whole thing and it is just about enough to counteract the full 15 knot crosswind, so the pedal travel may be a little bit excessive.

RUNS 866-867 Pilot 12, .5"RP, 7lb BO, 5.22lb/deg, LTR, APP

Mostly, I'm trying not to use the vertical translation. I find as I get down in the flare, natural tendency is to pull up and even if I break that deadband, no matter how stiff it is or no matter how stiff you've got it, that's altering how far I float down the runway.

I don't think it is too much authority. I've just got to train my hand not to pull back on the stick when I flare.

I am pulling back as well as up.

I wouldn't change the sensitivity just yet.

The amount of pedal force to get things to move seemed adequate, but the throw to me seemed just a wee bit too short, a wee bit too chopped. Sorry about that. It just is. Satisfactory without improvement. No. A 4 for that reason. When I wanted to put in what I felt was a nice amount of rudder, I had to stop and just left it there until the airplane settled down.

RUNS 868-869 Pilot 12, .5"RP, 7lb BO, 6.71lb/deg, LTR, APP

I am chopping throttles prior to touchdown.

Since I'm trying more of a banana flare maneuver, once you get through the banana if you leave the power up it is not going to do you any good. If you are just trying to bend it around a corner, you need the power to help you turn but after you turn the corner, forget it.

On that one, I seemed to be on the full stops either side so what that tells you I don't know. I just used the mode either as full and at the end it seemed like it wasn't quite enough to keep me from developing a side draft. So I was trying to get the correct amount of bank in there, also, which caused an oscillation back and forth so minor but annoying deficiencies, that a 4. I couldn't get things really precise. I think part of it is I was worrying about the vertical translation in the stick over here.

I was on the stops most of the time. Either all or nothing.

RUNS 870-871 Pilot 12, .5"RP, 7lb BO, 8.06lb/deg, LTR, APP

Another comment on the vertical translation here, it was much more comfortable with the twist throttle yesterday, I found out, than this thing for the same type of vertical translation. Another thing is that unless I purposely remember to do this at the start, just align at the start right/right and left/left, etc., I find that I'm still pushing the wrong rudder pedal to line things up, so maybe a couple of runs later with this same mode but with the pedals reversed, in other words, left pedal will be a right force, right pedal would be a left force...

On these two sets, I'd go up to a 3 on this particular rating and the reason is I wasn't on the stops the whole time and especially the last approach, I found myself starting to adjust the way the airplane was performing on the way down, in other words, I could feel with my foot a rate to put in, it may have been a wee bit excessive, I don't know but the end result is that I felt I could get rates down more precise control out of the aircraft...

Well, it felt pretty good. I think if you lessen the force on the pedals just a bit, I could get even more precise with it. Just a hair. But that's out of your test matrix probably.

RUNS 872-873 Pilot 12, .5"RP, Reversed Sign, 7lb BO, 8.06lb/deg, LTR, APP

That's even worse. On the sign reversed I thought it would help with the point...you mentioned that other mode which might even be better, but this is worse it's even more confusing, so the pedal forces are the same comments as before, but because of the sign reversal, I'd go down to a 6. That's just more confusing to me; it doesn't feel natural at all.

The reason is I thought it would help to get on it early and say well, I'm going to keep the crab going. I'm going to do it with the foot that would normally take the crab out if I wanted to take the crab out, but it is not working that way. It is much simpler to go right as right and left as left.

The reason is, as I stick in the left pedal I've got to take out a right crab and I've got to go left, so if I say left pedal, left bank, my mind says my airplane is going to go left and I was fighting that tendency so it really isn't worth it.

RUNS 874-875 Pilot 12, TGSSC, .48in-lb DB, 3.58in-lb/deg, LTR, APP

The crabbed approach wasn't all conventional. I wasn't getting the response out of the thing that I wanted to, so I started throwing in normal control.

Bounced that one for you. The reason I wanted the second one is because the first one I purposed didn't put a whole lot of force in the controller. I just went up to a limit where I could feel that I was starting to grip the stick really hard and the second one I didn't bother with it, I just honked in there and really got things over. That's the reason why I'm going with a 5 on moderately objectionable deficiencies. Satisfactory without improvement is the same problem we had before when we had a twist grip, when you grip it to twist the darn thing, you lose sensitivity with your hand and fine movements become difficult when you've got a lot of tension built up in the muscles. For that reason I rated it a 5.

<u>RUNS 876-877</u> Pilot 12, TGSSC, .48in-lb DB, 1.79in-lb/deg, LTR, APP

You might as well forget your vertical translation over here because with all that force in my grip the last couple of settings, there is no way I can judge it up and down.

I think 4. Again, when I really wanted to get things moving over, I just grabbed the stick and went after it and lost the sensitivity in the hand. As far as the confusion problem, that's gone. Right is right and I just sort of ignore the feet as far as things go except when I want to aid getting things pointed in one direction, more using them as a pointer than anything else. The vertical thing I'm not even worried about so much it is more just forward/aft, right and left, and the twist.

<u>RUNS 878-879</u> Pilot 12, TGSSC, .48in-lb DB, 1.19in-lb/deg, LTR, APP

Here control is fine. Light touch, very nice. As the winds come over, watch the oscillations in the airplane start getting heavier and heavier. Rate it for a 4 for that reason. Where you need the precise control, the light touch is right down on the flare where you are feeling for the runway and you don't have it, it is not there so you are stuck with tight movements and what you think would be a feel for where the runway is and it is just not there. That's why it's a 4.

<u>RUNS 880-881</u> Pilot 12, TGSSC, .72in-lb DB, .90in-lb/deg, LTR, APP

I'm not using the vertical translation and the reason is I'm just having enough trouble trying to get the thing lined up and going down the runway precisely without having to worry about pulling my arm up and down and adding that much more pressure to my hands.

I am still having the same problem as before.

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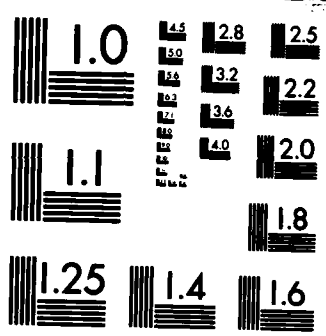

MICROCOPY RESOLUTION TEST CHART
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That time I had my eyes at the end of the runway and do you notice a stair stepping, that's very typical of white knuckle flying. You can't get a smooth anything going, it just jerks all over.

That's what a normal airplane would look like.

Same as before, when I needed the control my hand was really gripping to get things moving over, so it's a 4.

I tried both techniques on that final for you, I just used one and then taking the crab out and using the other. Again, it's difficult if you get a crab established to take it out and use the controller to take care of your nose/runway alignment problem.

<u>RUN 882</u> Pilot 12, TGSSC, .72in-lb DB, .72in-lb/deg, LTR, APP

It's the same thing, I had full right in and the airplane was still drifting left so I had to get the wings out of plane in order to reline it up and I was in the left drift when I landed.

The grip on the stick wasn't any better. I had full authority in there. I had no stop to judge it against. I just put in a full thing of wrist in order to make sure I had it pegged over and then I was using from there on, I was using bank in a second, I got those wings out it started dropping its nose like you said it would because it is a straight wide sideforce. Still a 4.

<u>RUNS 883-884</u> Pilot 12, 2"RP, 7lb BO, 4lb/deg, AZP, APP

It was weird not holding the other half of the cross control. I was afraid that when I put in that much rudder, the thing would start drifting left and I thought I saw a little drift left and I might have done something with my right hand at the same time.

My initial thinking was while I'm putting in so much rudder, I've got to do something with my hand.

I'll give you a 3 on that. Mildly unpleasant. It's a little bit unusual, but not as bad as before. Everything is completely normal, no confusion.

The forces were not bad at all, just fine.

<u>RUNS 885-886</u> Pilot 12, 2"RP, 7lb BO, 6lb/deg, AZP, APP

I'd give it a 2. Very, very adjustable, very predictable, and I think it is more pilot problems than anything else. Forces are fine, rudder pedals are fine. Just starting to get used to this sidestick again without any weirdness in it.

It seems entirely normal for some odd reason, it just does. It worked better when you put the command in gradually down final. Line the thing up and again I'm using it more as a fine tune device as you get close.

RUN 887 Pilot 12, 2"RP, 7lb BO, 10lb/deg, AZP, APP

I could do that on one for you, that's a 5. The reason is excessive pedal force to get the same response. I put a little bit in and nothing happened and I said, "Oh, no", so I just started putting it way in and it's way, way too much, I started concentrating too much on my feet and when I got down .....

RUNS 888-889 Pilot 12, 2"RP, 7lb BO, 2lb/deg, AZP, APP

A good 2. The forces were fine. Everything was very, very predictable. This thing seems to work like a normal rudder pedal in turns so everything is just normal/normal except you don't have any bank in cross control when the airplane comes straight away but everything works naturally. In other words, a normal cross control I touch one wheel first and the view would look tilted all the way through touchdown. Here it is not, it is just level, but that doesn't seem to bother anything at all. The approach itself was not very smooth and all but as far as the controls go, yes.

RUN 890 Pilot 12, 2"RP, 7lb BO, 1.0lb/deg, AZP, APP

That's down to a 4, because the pedal forces were too light, it was difficult to judge a rate. Other than that, everything was just like before. One comment I've noticed. It's difficult to judge, difficult to control something like a slip/slip--a drift across the runway because you tend to--you learn to do it with both controls but it wouldn't be that hard to just set a drift. Set a crab and then get down and gradually take it out as you approach the runway.

RUNS 891-892 Pilot 12, TGSSC, .72in-lb DB, 1.2in-lb/deg, AZP, APP

I'll give you a good 6 on that one and the reason is satisfactory without improvement, NO. Once I realized that I had to set up the velocity vector with bank, I started putting the bank in very, very light twist forces would get your feature working quite well so whenever I put a bank in and then put a bank in and I had to really concentrate on not putting any twist in at all, making a straight side force and that's kind of difficult especially when you are rotating your wrist away from your body. Response was fine, it was just too light of a twisting force that got that response for me.

RUNS 893-894 Pilot 12, TGSSC, .72in-lb DB, 2.4in-lb/deg, AZP, APP

I'll give you a 5. The reason is, as the wind kept shifting over. It's again kind of difficult to get the inputs going in through the same path all at once. When you require something really quick you have to get it -- it's a reverse motion. Like for instance with that I had a left crab ... was coming around. The nose is going to come around to the right but I still had to keep the left bank in so it's very difficult to judge how much to put in.

RUNS 895 Pilot 12, TGSSC, 4.8in-lb DB, 1.2in-lb/deg, AZP, APP

That's the same kind of problem. Rate it a 5. It's difficult to judge how much bank to put in and so forth and so on. To judge that drift as the wind keeps coming on around.

RUNS 896 Pilot 12, TGSSC, .72in-lb DB, .8in-lb/deg, AZP, APP

Strong 6. Way, way way too touchy. Any twist at all, trying to get the thing to bank either left or right, got everything all messed up. It's very easy to overshoot things and very difficult to get it to go to a place and sit still.

It would only twist when I twist it. In other words, I would concentrate first on just putting a side force into the stick controller. But then, for some of the other banks, I just banked left and I would put a twist in by myself. I'd say oh, no there's a twist in and then try and ring it out and at the same time keep the left bank in or the right bank in or whatever and that's when things were getting haywire.

RUNS 897-898 Pilot 12, TGSSC, 9.6in-lb DB, .8in-lb/deg, AZP, APP

Much better.

I'll give you a 4. While upping the deadband was a very big improvement, I could make bank inputs quite readily without putting any inadvertent twists in there. Once I did get past the deadband what a response I got. So it's again a little bit difficult to set naturally. With the wind cranking around linearly down to touchdown, again it was difficult to keep the drift from starting left or right as a function of why you've got bank it over, bank it over, bank it over. However, with respect to where I would set a bank and then use the twist grip to aim the nose the thing's just fine.

RUNS 899-900 Pilot 12, TGSSC, 9.6in-lb DB, .96in-lb/deg, AZP, APP

5. Again, a little bit touchy. Once I got past the deadband it was easy to overshoot. I didn't have so much trouble with the bank adjustments that time but I guess I knew what to expect. So it's a 5.

RUNS 901-902 Pilot 14, 2"RP, 7lb BO, 5.97lb/deg, LTR, APP

It was controllable. Adequate performance and a tolerable work load. I'd probably say yes but it's not satisfactory without improvements. I think at this point I'd rate it a 6, requiring extensive pilot compensation. I really didn't feel comfortable trying to accomplish the task. I had to learn plus work harder. I'd say it's very objectionable. I'm not quite sure how much effect I'm having with the rudder because I'm also controlling with some bank inputs.

Again, I suppose I would say the harmony isn't quite good. Perhaps that's a result of how much power I have in the rudder. But you're putting in an awful lot of displacement there and not getting the feel of the airplane that you don't really know how much you're doing. You don't have real feedback perhaps because you haven't just flown the airplane around straight and level. Maybe you've got a feel for what certain deflections give you. I'd say that leads you back -- You're working two controls to solve the problem; both bank and the translation. But perhaps not quite sure how much one is really doing the task.

RUNS 903-905 Pilot 14, 2"RP, 7lb BO, 2.98lb/deg, LTR, APP

Well, I adapted to it a little bit. The forces required for the rudder deflection were a little lighter it felt like that time. I ended up at the end of the whole rudder deflection. I can say it's just barely enough to kill the drift.

That series felt a little more comfortable. Probably just the learning curve. But it was controllable, tolerable work load. It's not satisfactory without improvement. I'd call it moderately objectionable deficiency. Give it a 5. There again, mainly because it's not being able to predetermine. It's kind of a hunt and peck solution to the problem rather than knowing exactly how to solve the problem.

It's more difficult to sort out what's going on than if I were trying to do a wings level approach.

I would say, at the present time, yes. It's a little more difficult. But only because I'm not accustomed to solving the problem this way.

RUNS 906-908 Pilot 14, 2"RP, 7lb BO, 8.95lb/deg, LTR, APP

It was controllable, tolerable workload. I'd say it requires improvement, though. Probably the same. I'd give it a 5, a higher 5 than before. So I'd say it requires considerable compensation. The response isn't automatic. It's still thinking about the controlled inputs and how they're counterbalancing each other. That's kind of how I judge as far as work load and compensation goes. A lot of it's based on if I have to consciously

work. That's quite a lot of compensation. If it comes naturally then that's not. At the moment it's still requiring lots of conscious correcting.

The forces don't seem too bad. It seems like they travel more than it was yesterday.

That becomes noticeable. I mean you would eventually adapt for it. That kind of starts disrupting the harmony when you're shoving your whole leg all the way over to get a required minimal force with your hands.

With a conventional centerstick airplane that would lend itself when you're talking about movements with the stick coupled with large movements with your feet. This, when your legs are all over, but your hand isn't moving, it doesn't seem natural.

<u>RUN 909</u> Pilot 14, .5"RP, 7lb BO, 5.22lb/deg, LTR, APP

Pilot's comments lost.

<u>RUNS 910-911</u> Pilot 14, .5"RP, 7lb BO, 3.73lb/deg, LTR, APP

It was controllable, tolerable work load, satisfactory without improvements. I would say no and give it a 4 requiring moderate compensation, minor deficiencies. I like the short rudder travel a lot better. Not Level 1 category there mainly just because I'm still not quite sure of input and response characteristics. It's just a learning curve I would guess.

I'm not having any trouble with the forces really or controlling them. Seem to have a finer feel especially when I reduce the rudder input as far as seeing the reaction to the actual displacement of the aircraft pretty quickly. Obviously with the crosswind the input of the rudder is more noticeable when you're taking it out as opposed to putting it in. In other words, putting it into the wind it's hard to judge what you're doing. As soon as you start easing it out then you can see the response visually right away.

<u>RUNS 912-913</u> Pilot 14, .5"RP, 7lb BO, .75lb/deg, LTR, APP

Well, in a way I think I saw where it comes from and I think it does. It comes from if you start banking to the right, even a small amount. It almost seems to be a cumulative effect. In other words, if you just nudge it with bank to the right, the nose will slowly come around. You don't have that problem if I make the initial correction with left bank and then stay over there now the nose is to the left which looks kind of natural and then make small adjustments from there. Make a lot of small, right roll adjustments and the nose will slowly be coming around to the right. I would still rate that one the same as before as a 4. The rudder pedal forces were lighter which I didn't particularly care for but I don't think it really affected the work

level of the task. I just didn't care for it as much. Just a little too loose. That's too loose. Whatever setting that is there's virtually no feedback. In other words, it feels like if you let go of the pedal it would stay there. It won't but it just gives you that impression.

RUNS 914-915 Pilot 14, .5"RP, 7lb BO, 2.24lb/deg, LTR, APP

Okay. That was controllable with a tolerable work load, but deficiencies warrant improvement. I'd rate that a 5, requiring considerable pilot compensation. It wasn't necessarily the force of the rudder pedals. The force didn't seem all that bad. It was better than the previous set. It was really just the feel of working to control the flight path of the airplane. I think that you tend to make larger inputs with the roll and the fact that you really don't have direct control over where the nose is. It starts to become slightly confusing. You can't use that as a traditional feedback that it really means to you because now where the nose is pointing has, in a way, lost a lot of its meaning. That's what I meant by it can become confusing at that point. The nose is off to the right, but I am really translating to the left, but yet to get the nose back to the left I'm going to have to bank the airplane to the left in order to get the nose back around to where I like it. A person would almost have to learn to ignore where the nose was except that it wasn't pointing where you might want it.

RUNS 916-917 Pilot 14, .5"RP, 7lb BO, 5.22lb/deg, LTR, APP

That approach felt real good. No problem controlling right at the target touchdown point. But there again the correction was to the left to get offset. The wind was from the west so the nose always stayed to the left which looked very natural. I don't think you have a problem with this unless you would say do more maneuvering on final. Say you were in the weather being maneuvered and you know you're not going to have the luxury of seeing the runway all the way at the start of the task like you do here. So I can forsee that you can break out of the weather with a left cross wind the nose is going to be pointing to the right. That may not be any big deal. But the thing is now you don't have any quick way to bring the nose around or point it straight or a little bit to the left. Because if you really had a cross wind, you sure wouldn't want to actually touch down crabbed a bit to the right. You don't have much time and the way to do that task would be to fly an offset task or something at 200 feet to try to correct over to the right hand side of the runway or something.

Based on those sets of runs I'd still say it needs improvement. I'd rate that a 4 because for this particular task only moderate compensation was required. There again, like I say, it's really a function of how many corrections you put in there to where you end up.

Those forces felt fine too. I didn't have any trouble with those. They certainly weren't too heavy. They were bordering to be too light if anything but they were comfortable.

RUNS 918-919 Pilot 14, .5"RP, 7lb BO, 8.06lb/deg, LTR, APP

As far as a rating goes, I'd still give it a 4, moderate compensation. The rudder pedal forces were too heavy. I didn't particularly care for that. Again, they're just way out of harmony with the other axes. It's almost like giving the response. It's just a different physical feel in order to get the response and I don't like it as much.

RUNS 920-921 Pilot 14, .5"RP, 7lb BO, 6.71lb/deg, LTR, APP

I flew that one just as a normal approach. That was kind of interesting what happened that time. It's like I banked in almost enough crab to take out the cross wind. Then I was left with no place to use my translation capability. In order to use that I'd have to bank out the crab I'd put in in order to start drifting so I can stop it. So there again, that's a case where I'm in a position where I've got the crosswind killed with crab, I've got no way to straighten out the nose. It just kind of happened that way. I just quickly ended up with that much crab in. I sat there thinking "Gee, now what do I do? There's no sense pushing on the rudder because I killed the wind and I can't straighten out my nose." That's what I mean by that could go to even more extremes than it did there.

I'd still give it a 4. As far as the forces go, I think they're still a bit too heavy for my taste anyway. The response appears to be getting more predictable as I fly more and that approach went fairly sensible and I was translating plus using some small bank. But rudder pedal forces were kind of high.

RUNS 922-923 Pilot 14, .5"RP, 7lb BO, 5.22lb/deg, LTR, APP

Okay, as far as overall rating. Still rate it as a 4 as far as the characteristics go. As far as rudder pedal force goes, that's not too bad. For me that's probably about as heavy as I would care to have it. I don't find that totally objectionable. For me that's about the outer bounds as far as force required.

RUNS 924-928 Not performed.

RUNS 929-930 Pilot 14, 2"RP, 7lb BO, 4lb/deg, LTR, APP

It was controllable with a tolerable work load, satisfactory without improvements. Kind of right on the borderline between yes and no to that question. I don't know, I think I'd actually probably give it a 3. As far as doing that part of the task. Pointing seems to come quite naturally and the forces and deflections right now seem pretty good. In other words, in spite of

the length in rudder travel, the harmony seems to be good. That rudder travel is tied with actually seeing the nose physically move a rather large distance so it doesn't present that sort of harmony dilemma that some of the other modes seem to pose. I didn't have any trouble with the forces. It seemed quite reasonable. There again, since it does require a large displacement, I quite naturally going to expect I'm not going to like a very heavy pedal force. But as far as doing the task to straighten the nose, it seems to work quite well.

3. There again, like I said, I'm rating the task just really eliminating the yaw prior to touchdown.

<u>RUNS 931-932</u> Pilot 14, 2"RP, 7lb BO, 2lb/deg, LTR, APP

That one didn't turn out too good. I was still drifting to the right when I tried to correct there but there again as far as just straightening out the nose I would still rate it as a 3; minimum compensation is required. As far as the forces and displacements go, they were still acceptable I would say; bordering on getting too light. Probably acceptable at this point in the motion of the nose in conjunction with the displacement seems to be very predictable and responsive. I almost already know exactly what kind of response I'm going to get for the controlled input.

<u>RUNS 933-934</u> Pilot 14, 2"RP, 7lb BO, 10lb/deg, AZP, APP

The turbulence isn't really giving me any problems. I'm having a little trouble really killing the drift right there at touchdown which that may be contributing to. Maybe it's just me and I'll work a little harder there right at the beginning to get moved over and lined up. Still controllable. Tolerable work load without improvement. I'd rate this one as a 4; probably moderate compensation with minor but annoying deficiencies. Probably is just really a heavier pedal force. It seems to take away from the predictability of the response and being able to really once it got almost full deflection, then you kind of lose the fine tuning capabilities there. Then the heavier force really does throw out the harmony as well. It just doesn't seem quite right.

<u>RUNS 935-936</u> Pilot 14, 2"RP, 7lb BO, 6lb/deg, AZP, APP

Minimal pilot compensation required. Yes. It's a 3. Certainly a lot better than the previous one I gave a 4 to. The forces, just for me they're probably about as heavy as I would like to see. It would probably be more acceptable to have it lighter but it's not unacceptable the way they are.

RUNS 937-938 Pilot 14, .5"RP, 7lb BO, 3.5lb/deg, AZP, APP

As far as pointing the nose, it's hard to say. It's certainly controllable, tolerable work load. I'd rate that as a 4 requiring moderate compensation. I didn't really have to -- didn't really use the mode that much just pushed it prior to touchdown. But I noticed with the short travel the response just seems much faster because I don't have the feedback or the physical displacement to kind of help me with positioning that. So I'm just kind of slamming it all in at once. The actual response is the same but my input just looks now like it's going to make the task a little harder having the shorter rudder travel.

RUNS 939-940 Pilot 14, .5"RP, 7lb BO, 1.5lb/deg, AZP, APP

I'd give it a 4. There again I don't like the shorter rudder pedal as much as I did the longer one in this particular mode. The main reason is I'm not comfortable with the predictability of the response to the input. As far as the forces go, I didn't really detect a lot of difference between the two I don't think. The last one was probably lighter than the first set if it was changed. I think maybe with a heavier force it might become less uncomfortable. With sort of a lighter force there I just don't like that predictability of the response. Kind of pushing it and see what happens and then starting to diddle with it instead of knowing what I'm going to get.

RUNS 941-942 Pilot 12, 2"RP, 7lb BO, 300lb/g, WLT, APP, Motion Disturbances

I was just using the pitch mostly to keep the velocity vector inline and once you reminded me I had wings level turn capability, I started using my feet. Up until then I was using the bank. That's the only thing that was different. As far as the turbulence is concerned, the jouncing around is good moderate level turbulence jounce. It's not severe but the reaction you see on the visual presentation doesn't match the bouncing around. In other words, there's a lot of bouncing around but the nose doesn't move. So if that's the intention, you have achieved your objective.

If you're for a realistic type simulation for a T-38 fighter type aircraft, the nose would be moving a whole lot more. As far as your rudder pedals and all being able to do the job, it's up to a 3, mildly unpleasant deficiency is that they're a wee bit mushy and a wee bit -- Well, the throw isn't really that bad but it's just a wee bit mushy.

I pretty much try just to hold the wings level.

Since I don't have side to side reference here, I'm sort of doing a half visual, half on the instruments. I'm scanning close, near far. I pick up the centerline as I get closer, like about 150 feet real serious. Up until then I'm just using a big white line as a pointer down the middle of the runway.

Chasing the nose around was getting more in a typical range for moderate turbulence. It was moving quite a bit more. The pitch is a real witch which is a real characteristic of high performance aircraft. You've got to watch yourself in pitch. Otherwise it'll just run away from you. So nothing out of the normal there. Again, a 3. It's a little bit mushy on the rudder pedal but not that bad.

RUN 943 Pilot 12, 2"RP, 7lb BO, 200lb/g, WLT, APP, Motion Disturbances

The only problem I had again was with the references on the localizer. On the localizer instruments that I've got before me, things are very, very clear. Especially on the raw data localizer. I've got a center marker and I've got graduation side to side. So when that thing moves off, I'm used to saying it's that far off. I'll put in this amount of correction, set it and see what happens. That's why you saw that S through final, lateral S. I went to one side, then the other and then all of the sudden caught on. I think with a couple of runs it may split out a little better once I get used to using the HUD. The HUD is fuzzy. It's not sharp and clear like the needles that I normally use. So as far as being able to put the airplane where I want it, no problem at all. The only difference from normal techniques is I'm not using bank, I'm using my feet. A little bit slow on the response of going through but it was plenty adequate as long as you stay on it all the way down approach. The rating for the rudder pedal's performance I think was again a 3. Apart from being a little bit slow and again for the pedals, still the same mushyness down there. It's sort of like indefinite for a feel. But nothing really drastic that requires a whole lot of compensation.

RUN 944 Pilot 12, 2"RP, 7lb BO, 500lb/g, WLT, APP, Motion Disturbances

Turbulence is still fine. There's really no problem. The controller again is adequate. I'm getting used to the HUD. I'd give that one a 2 because I like the feel of these pedals a lot better as long as you don't have to jam in a whole lot. If you stay with it right away, very, very nice; very, very precise. Able to keep the localizer bar well centered. Reaction very good. No basic change in technique. Still using just the feet for side to side and the pitch for up and down.

The turbulence is a factor to take into consideration but it's not really hindering the approach at all.

<u>RUN 945</u> Pilot 12, 2"RP, 7lb BO, 100lb/g, WLT, APP, Motion Disturbances

The same comments on the turbulence affecting the approach. While there's a lot of jouncing and bouncing going on, the nose isn't moving much. So it's really not very critical as far as upping the work load. I'm flying the thing almost as if there were really no winds; just ignoring the jouncing and the bouncing around. That one; however, the rudder pedals were a good deal mushier and if the inputs had been large would have been difficult to gage. So I put that down to a 4. Again, because I was right on at the first, that helped quite a bit. If I was offset it would have been quite a job to get that thing together with the feel I had for the rudder pedal that time.

<u>RUN 946</u> Pilot 12, TGSSC, .48in-lb DB, 240in-lb/g, WLT, APP Motion Disturbances

The same comments on the turbulence. However, that twist grip I just despise. That's a 5. The reason is, I twisted it, didn't move and in order to get any reaction out of anything I had to really get on it, grip it and move it all over the place. That took the feel out of my hands. I tried one technique going basically two dimensional. Either I made a side input or a vertical pitch input. While they were real fast, I didn't try combining anything because I had no real feel because there was no reaction. I kept twisting and twisting and twisting and nothing would happen. So that's a 5. Small temptation to just forget about that noise and just use the wings, the ailerons.

<u>RUN 947</u> Pilot 12, TGSSC, .48in-lb DB, 80in-lb/g, WLT, APP Motion Disturbances

Much better that time as far as precision control. That goes all the way up to I'd say a 2. That was very, very controllable; very, very precise. I didn't try any blended controls. In other words a twist and roll over or pitch at the same time. It was always either one or the other. However, the corrections needed were so small that a blended input was really necessary. What I was using it for, I could fine tune everything real easy. I just fell asleep right at the end and wasn't really on the corrections. That's why I didn't line up on the centerline for you.

The problem would come in if I was offset like say for where I was. Like two miles out, if I was like 500 feet left or right. I let that situation go until I was close in. Then moving things all at once might cause a problem.

<u>RUN 948</u> Pilot 12, TGSSC, .48in-lb DB, 40in-lb/g, WLT, APP Motion Disturbances

On that one far out on final. No real problems. The nose is moving around a little bit more this time. I don't know whether that's the simulator or me. However, I still felt the controller

was quite adequate to do the job. Found myself grabbing ahold of it quite tightly about half way down the approach. However, when I said okay, relax and just use your finger tips, things went back to quite a bit normal. The only real problem I had was with really precise control down in the flare. This might be a function of how hard I'm gripping the stick. So no real big deal. The landing still came off quite well. I thought a little off the centerline to the left. So it's a 3. No basic change in technique. I'm still using either left or right or up or down as the way to control. It's either/or. Trying to keep the wings level; if they get out of level I just put them back and don't really worry about it.

RUN 949 Pilot 12, TGSSC, .48in-lb DB, 30in-lb/g, WLT, APP Motion Disturbances

It's a 3. Again, quite adequate to do the job. No problem. Very, very light touch required on the controls. If you start white knuckle flying at all, a really good grip on the controls, you'll overcontrol the thing because it was sensitive. That's why the down rate to a 3. You might have a little bit of a trouble with that it you're really on a tense approach and the pucker factor is really up. You might be just a bit too responsive.

RUN 950 Pilot 12, TGSSC, .48in-lb DB, 30in-lb/g, WLT, APP Motion Disturbances

That tightened it up a wee bit. That may have been -- I'd put that down to a 4 just a little bit because I had my eyes going all over the place that time. Especially down close where I'm trying to look for decision height, the runway and keep my hand from doing all sorts of weird things to get everything to stay in the same place. A little bit too touchy. Still quite doable.

RUN 951 Pilot 12, TGSSC, .48in-lb DB, 80in-lb/g, WLT, APP Motion Disturbances

That felt a lot more controllable, especially down close. For large inputs I had to grip the stick quite well. However, once I got things narrowed down to a very narrow window, things were okay. Then down visual-wise I just settled for landing right of the centerline. So I'd bring that one to a 3 at least. I take that back. I'd make that a 2 because it was very controllable, very solid feel down close. Not objectionable at all.

Is this as heavy as your turbulence gets?

It's not severe. It's I'd say barely a good definition of moderate.

<u>RUN 952</u> Pilot 12, 2"RP, 7lb BO, 500lb/g, WLT, APP, Motion Disturbances

On that one, the task was tightened up a little bit and it's not as bad as the one crosswind section you had before. The huge deviations on localizer final were I think me more than anything else. Once I was on it really tight, controlled tracking type thing with the ILS, the pedals were very, very nice as a precision instrument. A little bit hard for large inputs; a little bit forceful. But as far as a fine tune thing, quite controllable, quite nice. I give it a 3. It was just below the edge of being a little bit too stiff. But I felt that because of the precision I couldn't get out of the whole idea. That's why the rating of 3 instead of 4.

<u>RUN 953</u> Pilot 12, 2"RP, 7lb BO, 500lb/g, WLT, APP, Motion Disturbances

I'd give you a good 5 on that. Rudder pedals were way too stiff. Did not like that at all. Had no feel, no real precision down on the approach. It felt more like an on/off switch. As soon as I saw things move, I had to get off the pedals. The finesse that was present before was not there at all.

Noticed a slight downdraft, I think, on final. But nothing really excessive. It got a little tight toward the end but I couldn't really tell whether it was your turbulence or me overcontrolling with the pedals. Once I got a good force going, enough to get things started moving, things really started happening awful fast. So it was difficult to tell whether it was the wind shaking the airplane or me shaking the airplane which was causing some of the problems. But again, task quite doable, no real difficulty.

<u>RUN 954</u> Pilot 12, TW, .25lb DB (est.), 25lb/g (est.), WLT, APP Motion Disturbances

Everything as far as the right hand was concerned, the comments made before about feel down a flare and all that kind of stuff really don't apply here. It's normal up/down, right/left. As far as the directional control with the wheel goes, I felt it was a little bit too stiff. In other words, I had to use too much thumb pressure to get a response out of the airplane. As far as controlling the airplane, though, it was precise and I don't need a feel in my left hand because there's nothing to move around. So I can grab that stick, fool around with it all I would like. So it was a minor annoyance. That's why it's a 3. It felt entirely natural. Like I said, it's much better than that twist grip.

RUNS 955-956 Pilot 12, TW, .25lb DB (est.), 12.5lb/g (est.), WLT, APP, Motion Disturbances

The difference was that the first time I noticed myself using the thing as more of an on/off switch. I would stab at the wheel just to get the thing to move around. This time I purposely tried just to keep my thumb on it, moving slowly and I found that it was just as good to use if you were trying to get a rate going. For instance, like just move it over so much, let it stop instead of just having it jerk all around. Either way, the thing was plenty adequate to do the job and actually not all that unpleasant to use. So I'd still give it a 3.

RUN 957 Pilot 12, TW, .25lb DB (est.), 6.25lb/g (est.), WLT, APP, Motion Disturbances

I think I'll stick with using it as I described secondly. Don't use it as an on/off switch especially the way that one was set up. Very nice control. Very precise. I got confused sometimes on the directions but that was because I started changing sides of the wheel with my thumb to use. That's no big deal. I'd give it a 2. Very nice. Very controllable.

RUN 958 Pilot 12, TW, .25lb DB (est.), 8.33lb/g (est.), WLT, APP, Motion Disturbances

Same as the first. Nice and controllable. The first one before this one. Nice, controllable, precise. Even down in the flare that was my eye's problem; the reason why the flare got all messed up right at the end. A 2.

RUN 959 Pilot 12, TW, .25lb DB (est.), 8.33lb/g (est.), WLT, APP, Motion Disturbances

Overall very controllable again. Down on the flare though you have to watch yourself. It's a wee bit sensitive, a wee bit much. If you try and do a lot of little corrections, as you get right down to the thing, it tends to throw the airplane side to side. But I don't think that's bad at all. That's very liveable. I'd rather have it that way than it not move at all. The turbulence was a little bit worse but not that awful bad. Didn't inhibit the task in any way at all. So I'd still give it a 2.

RUN 960 Pilot 12, TW, .25lb DB (est.), 8.33lb/g (est.), WLT, APP, Motion Disturbances

Definite increase in turbulence level. That required a good deal more concentration just to get things rolling. As far as the controller is concerned though I'd give it a 3. Again, that is indicative of the amount of response I get out of it once I notice things starting to move rather rapidly. In other words, I pitch down, pitch over and all of a sudden we drifted way far left and way far right then coming left again. I was really working both hands really well. The one thing I am noticing though

is that with the ability to use both sides of the wheel, I have to keep reminding myself to keep my thumb on the one side so things stay left is left, right is right. That's neither here nor there. It's just getting used to left is left and right is right.

I use the edge of the wheel. That's much more precise. So every time I switch edges, I switch rotation direction. But it wasn't as bad on that approach.

Actually, I don't take my thumb off the wheel. I just move it left to right. So as far as controllability goes, still very controllable. It responded enough so that I could deal with whatever was happening to the aircraft quite nicely.

If the motions of the simulator cab are sustained motions they affect the movement of my thumb. Relative light bumps I don't have a tendency to worry about. What I do worry about though is if I see a sustained drift building up its influences what I do with the controller. I don't think the motion is causing me to make inputs.

<u>RUN 961</u> Pilot 12, 2"RP, 7lb BO, 500lb/g, WLT, APP, Motion Disturbances

Not bad at all. I'd like to give that a 4 basically because a little bit stiff on the rudder pedals, especially if I had to make a relatively large input or a large type of correction. Other than that it's very, very controllable; very, very precise even all the way down through the flare. So I give it a 4 just because of a little bit excessive on the rudder pedal pressure.

<u>RUN 962</u> Pilot 12, 2"RP, 7lb BO, 500lb/g, WLT, APP, Motion Disturbances

That definitely was a little bit rough on the turbulence. As far as controllability I give these things a 4 again because of the rudder pedal pressure. It's still too stiff. It took away from some of the controllability when things got lumpier and bumpier. As far as comparison to the thumbwheel, the thumbwheel at the lighter settings I feel was a bit more precise. However, the rudder pedals are a bit more goof proof. In other words, right is right and left is left all the time instead of being able to switch sides on a thumb wheel. Now that may be a function of the placing of the wheel. It may be a little bit more conducive if I can only get to one side of it.

If you look at a wheel from the top, if I put my thumb at the right edge where east would be on a compass. . . I'm on the edge of the upper surface of the wheel.

My thumb is on about southeast on a compass, looking down on top of it. Now it's very easy to put your thumb in the position of southwest or west, for instance. If you push forward or back in that position the direction changes. So that was a wee bit on the negative side.

The motion with the thumb is fore and aft like this. But the button of course goes clockwise/counterclockwise.

When I push forward I expect the nose to come left. If I pull back I expect to come right.

Now the rudder pedal you can't do that.

<u>RUN 963</u> Pilot 12, 2"RP, 7lb BO, 500lb/g, WLT, APP, Motion Disturbances

Again a 4 for rudder pedal pressure. However, it's still very controllable. The task is very doable.

<u>RUN 964</u> Pilot 12, TGSSC, .48in-lb DB, 80in-lb/g, WLT, APP, Motion Disturbances

I don't like it. I'll give you a 5. The reason is in order to get response out of the movement in front of the aircraft, I had to really get a grip on the darn thing. So there's really no feel, very little precision. I tried moving two ways at once; like pitch and twist at the same time. Very unprecise. Much more of a tendency to either twist or change the pitch. Either/or but not both. The turbulence effects may have an effect if they're very, very rough by causing wrist and things to move around trying to combat that thing with everything all on one hand.

<u>RUN 965</u> Pilot 12, TGSSC, .48in-lb DB, 240in-lb/g, WLT, APP, Motion Disturbances

Give you a 6 on that one. I really had to yank on that thing and that was a concerted effort to try and use the twist grip in order to get the thing down on the ground. I would much rather have used the ailerons.

<u>RUN 966</u> Pilot 12, TGSSC, .48in-lb DB, 80in-lb/g, WLT, APP, Motion Disturbances

Very nice. I give that a 3. That's very precise. Still the problem with when I want to turn abruptly, especially if I have to change directions like from left to right. I still have to grab the stick and reverse with my wrist. So a degree of feel is gone but not to any extent like it was in the run before this one. Very, very minor objections. I give that a 3.

RUN 967 Pilot 14, TW, .25lb DB (est.), 25lb/g (est.), WLT, APP, Motion Disturbances

Just general comments, it was quickly adapted to. The response seems very predictable using that controller. Flat turning aspect, no trouble adapting to it. Even with the turbulence there's not a lot of demand on the system, if you know what I mean, a series of apparent small corrections. With that in mind, I think I'd probably rate it as a 3 as far as being able to control it, do the task. It really requires minimum compensation on my part for the task given.

It seems to be all right. I should have a glove on for the little wheel's hard on bare thumb. It's no big deal.

RUN 968 Pilot 14, TW, .25lb DB (est.), 8.33lb/g (est.), WLT, APP, Motion Disturbances

Exact comments lost. Notes from the run log indicate that the pilot said the configuration was predictable, more responsive and quicker than previously, and that he in general liked it better. He gave a Cooper-Harper rating of 3.

RUN 969 Pilot 14, TW, .25lb DB (est.), 6.25lb/g (est.), WLT, APP, Motion Disturbances

Exact comments lost. The run log indicates that the pilot felt the configuration was okay and gave it a rating of 3.

RUN 970 Pilot 14, TW, .25lb DB (est.), 8.33lb/g (est.), WLT, APP, Motion Disturbances

I didn't notice any big difference. I made a mistake of my own there. I switched my own polarity there. It went right up the end so I veered a little off to the right there and then over corrected. That was my fault. I kind of reverted to thinking of it like a trim wheel instead of the wheel that it is.

What I did was I sort of changed the way I handled my thumb on the wheel and I held it trying to keep my thumb in one position and just nudge it back and forth like you would a trim wheel. I think, because of that, I kind of reverted to thinking of it as a trim wheel. In other words, which is trim it to the right, you go to the right. That doesn't work of course and that's kind of reversed. I wanted to make a correction to the left so I moved my left to the left. However, that made me go to the right.

That time I held it at the base of the wheel without moving it. Before I had been actually sliding it from side to side depending on which way I wanted it to go.

Just kind of resting my thumb at the base of the wheel.

Like I say, I think that whether this polarity makes sense or not depends on how you look at using the wheel. If you're thinking long term like it's really going to be a wheel like that and it's going to be on the left hand controller. Like I say, I didn't have that problem until I changed the way I was holding my thumb. To keep a stationary thumb and then just use the pressure left or right, now you lose the fact that it's a round wheel and it's like a control knob while trim knobs work the other way. If I want to do something and go to the left or trim left wing down I move my thumb to the left.

Before I was moving it more or less from side to side. If I wanted to nudge it to the left I'd slide my thumb over or move the nose to the right rather than move my thumb over to the left and nudge the wheel up. That made sense because I was pushing up on a wheel toward the way I wanted to go and vice versa. I was pushing up on the wheel to the left to move around to the left. But it was only until I changed the way I was holding my thumb on the base and just be easy pressure to move it. That's when I found that one time I wanted to move to the left so that's where I moved my thumb and then the next thing I knew the nose was going to the right. I think if it wasn't the wheel, if it was just or if the wheel was rotated 90° forward so you were resting your thumb more or less on the top of the wheel if you see what I mean. If you're moving the wheel to the left or right, then I think you'd want the polarity to be such that moving my thumb towards the left, pointed my nose to the left. I think you can learn it either way. It was interesting that I just fell back into that mode of thinking and made a mistake.

I find that having my thumb like I had it on the last run where my thumbs pointing up, is more comfortable than having my thumb pointing forward.

That's kind of why I tried it. That makes more sense.

So I think I'd rather push my thumb to the left and the nose go left.

I think I wouldn't mind trying some runs that way to see how it would work out.

<u>RUN 971</u> Pilot 14, TW, Reversed Polarity, .25lb DB (est.), 8.33lb/g (est.), WLT, APP, Motion Disturbances

That felt pretty good.

I would still give it a 3, requiring minimum compensation. There's still some work and conscious thought going into my corrections. As far as response and predictability it was very good. I had no trouble adapting to having it changed to be that way. In fact, that seemed very natural especially if you just keep your thumb in one position, almost thinking of it like

another trim knob. If you give it half ratings I'd give it 2 and 1/2. Not quite a 2. It's not quite that good. But I think with the learning curve I would eventually be rating it as a 2.

RUNS 972-973 Pilot 14, TW, .25lb DB (est.), 8.33lb/g (est.), WLT, APP, Motion Disturbances

That one actually went pretty good. It actually translated to the left there but that wasn't me. That was the wind or something. I was correcting it out at the end. I would say based on accomplishing the task on that run I'd give it a 4 because on a landing like that I really wouldn't have been able to make it. I probably could have gone around. I'd say its band of response was predictable but was really inadequate right there at the end to compensate for the wind. It was requiring more work on my part.

RUN 974 Pilot 14, Exact Configuration Unknown, Repeated by Run 976

I give it an overall rating of a 3, requiring minimal compensation. It seemed to work pretty well as far as forces and displacements felt comfortable. The response was predictable even with some larger corrections there at the end, which again I think a little bit of wind there started to move it and corrections to the left or right hard either way, I forget which order, but large corrections at the end which it was coping with rather well.

RUN 975 Pilot 14, Exact Configuration Unknown, Repeated by Run 977

Well, overall it went pretty good. It responded against large corrections at the end quite well. Rate it a 3. I don't know if you changed the forces at all or not, but I suppose I would prefer the forces a bit lighter. Only for making the large corrections did it seem a bit excessive.

RUN 976 Pilot 14, 2"RP, 7lb BO, 500lb/g, WLT, APP, Motion Disturbances

Well, that didn't seem too bad. The forces are about as heavy as I can probably stand to have them. I would probably rate it as a 4 requiring moderate compensation. The overall response of a given change to the nose, it's a large correction. It takes some amount of time. I found myself having to consciously lead. If I felt I needed a large correction I couldn't put it all in. So I would end up with more than I really wanted. Almost kind of guessing at how much correction I have to put in because it seems a little slow and you have to guess how much correction you need to take care of wind that's moving you one way or another.

RUN 977 Pilot 14, 2"RP, 7lb BO, 500lb/g, WLT, APP, Motion Disturbances

I think I would rate that one a 5 requiring considerable compensation. Really quite a bit of work. Some of that's work caused by the increased turbulence. But nonetheless, like I say, it's like you have to sit there and almost anticipate what the wind is going to do. You have to be very fast and pick up any change. Otherwise it's going to result in like an overcorrection or you're going to get blown off track. It's like you really can't keep the airplane right down the center line. You're going to vary somewhat if the response isn't fast enough to get you right back. So if you're the least bit late in perceiving a change off one way or the other it's very hard to get it back around.

RUN 978 Pilot 14, TGSSC, .48in-lb DB, 240in-lb/g, WLT, APP, Motion Disturbances

Controlling the nose and accomplishing the task it wasn't too bad. I'd give it a 4, a good 4. It was just minorly annoying, requiring some moderate compensation. I think right offhand, I don't like it because it makes me hold the stick a lot tighter than I'm used to, especially in the landing mode. the motion to twist to the right is unnatural, much more effort than to left.

RUN 979 Pilot 14, TGSSC, .48in-lb DB, 80in-lb/g, WLT, APP, Motion Disturbances

I liked the forces a lot better. As far as its response in doing the task controlling the nose, just doing it, I'd rate it a 3, but I personally don't like using the twist grip to control that. I can do it, and keep the airplane lined up but I don't like it.

RUNS 980-981 Pilot 14, TGSSC, .48in-lb DB, 80in-lb/g, WLT, APP, Motion Disturbances

That worked out better. I had to work harder trying to really stay ahead of the game there and I had no trouble controlling it.

As far as performing the task in making the landing and controlling it I'd rate it a 3. I just find it physically not a comfortable way to do it.

RUNS 2001-2002 Pilot 21, 2"RP, 7lb BO, 20lb/g, WLT

--LEVEL TARGET--

You made it so easy we've run out of bullets.

--TURNING TARGET--

The target can be banking one way and I'm not really sure which way I'm banking, but you can stay on the target. Unless I consciously think about where I'm pushing on the aileron. You really don't have to use the aileron.

Overall, I'd give it a 3.

The first half I don't have any comments. It was -- everything was all right. The second task, the 2G turn, it took awhile. The pitch was a little sensitive but once you get used to that I wouldn't change it.

Pedal forces and sensitivity?

They're all fine. Control sensitivity -- I'd give it all a 3.

The first, when we were practicing, the rudder felt a little bit sensitive, but the second run we made it wasn't. I think maybe because of the picture. I should be wearing tennis shoes here, it would be better.

A little more feel.

Yeah, maybe I'll take my shoes --

RUNS 2003-2004 Pilot 21, 2"RP, 7lb BO, 60lb/g, WLT

--LEVEL TARGET--

Know what's wrong with that one? That one is almost too easy -- put you asleep. I fell asleep.

Once that -- you get steadied down on the ones that we're doing here, you can just think about moving your feet or your toes and you can hold it. If you want to roll the wings a little you don't have to think too much about doing that either.

You know one thing that's wrong with trying to fine track is our picture. Those cross-hairs and the tail of the airplane you don't really have an exact thing I can be on. I'm kind of keeping the vertical cross-hair on the tail and the horizontal on the lower part of the wing.

That's a big area looking on that picture.

I don't know why that's easier. I think I have more time to look at the airspeed maybe.

--TURNING TARGET--

A little bit of pitch bobble right there. It's hard to.

The wing level -- that was just like before I felt. Let's give it all a 3. The control feel, everything was good -- sensitivity.

I'm saying 3 because...

I think for everything except that last one I would say 3 to and then the 2G turn I would go into 4 and the deficiency there is the pitch bobble and it's probably just too sensitive. The harmony between the two are good. The rudder is sensitive too, but it's not as bad. You don't notice it as much in a turn as you do the pitch and I think that's what throws me off.

The pitch is not a problem. You can compensate, but I notice when I finally got locked on and then I tried to roll a little bit I'd pitch again.

I'm just going to rate the control sensitivity and pitch. There's plenty of authority and the feel's alright. The response was good, but it's too sensitive.

I want to ask a question -- do you all talk about control harmony when you're using these sidesticks?

Well the rudder and the pitch are sensitive, but so far the rudder doesn't bother me.

It took awhile to catch up with the target.

RUNS 2005-2006 Pilot 21, 2"RP, 7lb BO, 40lb/g, WLT

--LEVEL TARGET--

That could be too much of a good thing. You really lose concentration when you can stay on it like that.

The way the rudder works with your picture, it's really easy to move and to hold it. It's on the verge of being too sensitive, but not moving around much up there, it's not too sensitive.

--TURNING TARGET--

For the first run, we can almost go to a 2. I guess that's just cause it's you know practice makes perfect. It might be my imagination, but this turn the pitch if it was the same, I'm getting used to it, but it felt better. I'd give that one a 3. A 2 and a 3. I hate to give those higher ratings, but there's nothing much there that's bothering me.

Into the turn, it's hard for me to tell -- once you put a target in a turn, do you change its bank?

Okay, it's hard for me to tell if he's changing or if I'm not smooth enough -- you know I'm not holding.

RUNS 2007-2008 Pilot 21, 2"RP, 15lb BO, 40lb/g, WLT

--LEVEL TARGET--

I don't like this one as well. It feels like he changed the breakout forces.

--TURNING TARGET--

It was interesting. For the level turn I'd say between a 4 and 5 for the rudder.

Why don't we call it a 4. The reason because the delay was too long. You'd push and then you'd wait. You could get used to it though, but you'd already shown me one that I like better. The feel was alright and the forces -- it felt like not only in the breakout, but it felt like it took more force to hold the rudder. The airplane response for the rudder was it just took longer. I didn't like it. The 2G turn, why did it work better?

The 2G turn if I talked about that one, I'd almost give that one a 3. I'd say a 3 for the rudder and the pitch was annoying a little bit. Not that bad. I'd give that an overall 3.

I felt like I was holding on there, but I didn't like it as well for the level target.

RUNS 2009-2010 Pilot 21, 2"RP, 10lb BO, 40lb/g, WLT

--LEVEL TARGET--

So far it hasn't made too much difference which way I'm banked.

--TURNING TARGET--

Why was that one so good?

There wasn't anything that really bothered me on those. I can't even say what some mildly unpleasant deficiencies would be. It's still a little difficult in the bank to hold the pitch. It's not bad enough to change anything.

Let's give the whole thing a 2. Between a 3 and a 2. I'd probably say a 2.

That one was easiest of all.

I guess the scores are a good indicator, but it's -- the easier it gets it's easy to lose concentration.

We've got some funny lines back at the top of the picture.

Need another armrest in here, too. On the left side.

I just noticed it today using the button here I'm resting my arm on a little piece of metal. I have a small hole here in my arm where the screw goes through it.

RUNS 2011-2012 Pilot 21, 2"RP, 4lb BO, 40lb/g, WLT

--LEVEL TARGET--

This one is like it's not even moving. I don't get bored now. The screen is distracting me too.

That one was the easiest one of all until I fell asleep there and started watching everything else around me.

--TURNING TARGET--

You know that last one that I rated good in the 2G turn, we did that to the left.

It seems like it might be easier to go left than right, I don't know maybe not.

There's still a little bit of pitch bobble there.

The rudder you can almost hold right on the pitch. If you let that bobble, then the rudder gets off.

Let's give both of those a 3. The 2G turn, that's harder than the other one. It's hard to roll in and get steady, but once you get steady on it, if you pay attention to the pitch it's not hard to hold. I'd give it a 3.

It looks like it's not important unless you get into a big bank which way you're banking. You don't really have to think about it too much. Sometimes, I felt like I was banking opposite to the way he was turning, but I could still track it. The simulation I don't think has had any affect on our ratings except the one time when we got some squiggles up top I started paying attention to that and the noises I paid attention to that too.

And there's a little hole in my left arm from laying on top of that screw and that's not too big a thing. I'm not bleeding.

Mentioning, it's funny how I'm noticing little things now that I didn't before. This arm rest on the right, I rest my arm on the outer edge of it. It doesn't matter, but I guess...the arm rest on my right arm, I'm resting my arm on the outer edge of it, not on the -- if I've got it in it's too close. If it were movable I would move it outboard some.

Up and down it's fine. It's just I'm on the outer edge of it, the outboard edge.

Well it's comfortable. It's not uncomfortable, but I just don't use the whole thing.

RUNS 2013-2014 Pilot 22, 2"RP, 7lb BO, 60lb/g, WLT

--LEVEL TARGET--

Okay, you're not going to believe this -- I'm not sure how you'd. I don't normally give out 1's, but I don't know how you'd.

Let me say this, I think that this mode the way it's setup right now is superb for fine tracking. I really feel good about it for fine tracking and...

--TURNING TARGET--

Those two were the same, different target, right?

My conclusion is, it's this is brilliant. It's the function of the task for the first task, which was a low gain maneuver because the target was not maneuvering aggressively. I would rate it a 1. For the second task, I would give it a 4 and I would say -- either we have to change the system or have to compensate. The way I can compensate for that is if you noticed about half way through that I used more bank angle to compensate for lack of side force or lack of pointing capability there. I'm not using the right terms here.

So with the higher gain task or more difficult task, I had insufficient control authority so I was able -- I can compensate by increasing the bank angle and make it work which I did there in the second half of the turn, or the other alternative would be to increase the authority and probably you couldn't do that so basically the pilot has to compensate. I would give it a 4 because of that, but still, I think it's a superb -- well let me rephrase that. I think it's a very useful way of improving your tracking capability.

This rating is based on the task that I'm doing, so it's not a simple task.

RUNS 2015-2016 Pilot 22, 2"RP, 7lb BO, 20lb/g, WLT

--LEVEL TARGET--

I don't have trouble rating it. Didn't leave much room for improvement does it?

I give it a 1.

But it's hard to say how we're going to improve this, right?

--TURNING TARGET--

Right in here I'm holding left pedal, but I'm using it. Changing the amount of left. That's mostly pitch I'm having to work on right now. Off the target too. I think a range correction.

My preferred solution to handling that problem better would be to have more control authority. More level turn control authority, which says that I can't make it -- that I need to make it a 4.

RUN 2017 Pilot 21, 3"RP, 7lb BO, 60lb/g, WLT

--FAST LEVEL TARGET--

It's going to be hard to rate it because I don't like it as well as what we had yesterday. I don't like -- it's sluggish. Why don't we give it a, I don't have my script, but 4 is the separating line between do something.

Let's say 4 and it's just not as responsive as the other one -- not bad and probably if I hadn't seen the other one it wouldn't be that bad. Again, once you lock on you can stay but when he changes his bank it looked like I drift off and I have to push a little bit more pedal than we were used to. It lags and it takes a little bit to catch up, whereas when it was more sensitive you could stay right with it when he started changing directions. So, let's give it a 4.

I used more bank angle that time too than we did before.

Yeah, because before you could rudder it right in there and this one you can't so the next thing I would try would be to bank it.

See when we first started flying this thing, I chased around with bank, but then you realize you can do the same thing with rudder with less time. Now, today you can't.

RUNS 2018-2019 Pilot 21, 3"RP, 7lb BO, 40lb/g, WLT

--FAST LEVEL TARGET--

I think that was worse. I wouldn't go to a five on it, it's still around 4. The problem with that one, it seems like there was less response than before. Let's try that one again, I'm not sure about that. It felt like I was kicking a lot of rudder, but not getting much response from the airplane.

It's hard to tell. You know what it kind of feels like, that the rudders aren't as sensitive as they were before so I'm using more aileron and that seems -- because I was kind of bank rocking the wings there. I think I like it better when the rudders are more sensitive. It was like I was doing in pitch -- bobbling in pitch. I was bobbling around in lateral there. It's not bad. Is this the same as the one we just did?

Well it seemed better this time. Because, what I did, I used more aileron to track it rather than -- you kind of got me trained like a monkey. Before the rudders worked pretty good.

Well to track it and stay on, two times there I learned to use the bank. I'll use the rudder. By using the bank, I got bobbling around in bank.

Let's give it a 4, because if we're just going to say we're going to use the rudders, I can't track it as well with the rudders as I could before.

RUN 2020 Pilot 21, 3"RP, 7lb BO, 40lb/g, WLT

--TURNING TARGET--

Not too bad. But I think it's easier with less rudder movement.

Compared to what we had yesterday, I'd want to improve it a little bit. It's nice to me for the rudders.

Why don't we give that one a 4 too.

And again, that's just because of the increased motion that's required basically.

RUNS 2021-2023 Pilot 21, 3"RP, 7lb BO, 60lb/g, WLT

--FAST LEVEL TARGET--

We have enough authority. That one was more comfortable. I guess it's just getting used to it.

Yeah, let's do it one more time. It's getting really hard to tell now. Like that run wasn't too bad.

That would almost lead you to believe it was better wouldn't it?

Well if we just rated that one, I'd definitely have to give it a higher rating this time.

Let's give that run a 3, because that was pretty easy. My workload was really low on that one.

--TURNING TARGET--

Boy, I'd have to give that one something like a 3.

No problems.

That was a pleasant one. You know, maybe that's better. It's hard to tell because in the pitch I wasn't bobbling around that much.

Maybe the pitch axis is better too.

Let's give the turning target a 3.

RUNS 2024-2026 Pilot 21, 3"RP, 7lb BO, 20lb/g, WLT

--FAST LEVEL TARGET--

Let's do that one again. I didn't like that one. It was kind of lazy, sloppy.

It overshoots on me and I can't stop it. I don't like this one at all. Boy, there's no damping.

What does it say about a 5?

Yeah, why don't we say that. Once I get the movement going, I can't stop it.

--TURNING TARGET--

I think I'd give the turning target a 5, too.

Too loose. There's no damping at all. I just overshoot all the time.

RUNS 2027-2028 Pilot 21, 3"RP, 20lb BO, 60lb/g, WLT

--FAST LEVEL TARGET--

That's too high.

Yeah, what's below a 5?

As we go down the scale, let's see what have we got? Very objectionable but tolerable.

Let's go below that.

Major deficiencies -- adequate performance not obtainable with maximum tolerable pilot compensation, but controlability is not in question.

Okay, it's between that and the next one up. It's really bad.

Let's pick the one that's intolerable. I didn't really want that one. Cooper-Harper 7.

It's a matter of what it takes to start it moving.

Once you've got it going, you can handle it.

--TURNING TARGET--

My feet are getting tired.

Let's give that one one better than we gave the last one. It's not as hard, but it's still -- I don't like that. I think it's not as hard because he doesn't chink around as much. It seems like when he gets established in a turn he stays there pretty much.

It's a little bit easier, but I still don't like it and the same reason. Initial force. Cooper-Harper 6.

I got carried away with my rating before this, but I want you to know I don't like that.

RUNS 2029-2031 Pilot 21, 3"RP, 10lb BO, 60lb/g, WLT

--FAST LEVEL TARGET--

Let's say 4. That one was pretty good, but there was something about it. Seemed like the target was making lazier turns. Somebody was lazy, maybe not.

The response just seemed slowed down.

It wasn't too bad. Whatever force you've got in the pedals, it's just natural when I push and I don't get the response that I did get to go to the aileron.

--TURNING TARGET--

Right there I can really hold it on easy. Sounds like your simulator is ready to give up the ghost.

It's moaning and groaning.

I'd give it a little bit better than the level one. What did I say, 4 before?

Can we give it a 3 1/2? Give it a 3.

RUNS 2032-2034 Pilot 21, 3"RP, 15lb BO, 60lb/g, WLT

--FAST LEVEL TARGET--

I would say 4.

It's just too hard to push on the rudder before anything happens.

--TURNING TARGET--

That was the same conditions as the level turn.

Well that's funny. It was harder and if it really is a breakout force, it felt like it was. Then once you got motion again, I couldn't stop it when I wanted to. That one was harder than the level.

A 4 minus. It was more noticeable what I didn't like about that in that turn.

The turning target requires moderate compensation.

That puts it back at a 4 then.

Okay, let's call it that but you know most of the times I commented in the bank. It seemed like it was easier, but that condition wasn't.

RUNS 2035-2037 Pilot 22, 2"RP, 7lb BO, 40lb/g, WLT

--FAST LEVEL TARGET--

Adequate authority. Force is no problem. I really can't make any prominence on harmony I don't think because of the fact it wasn't used in sight forces and really a pedals only maneuver, so I'm not saying anything about that. Sensitivity--I didn't have problems with sensitivity--I did feel lag. I'm unable to make as precise heading corrections as I would like to. It seems to me like I'm using a side-slip or, you know, conventional rudders to point the nose of the aircraft. In other words, it takes a while for it to take effect and then when it does take effect, I generally get a little bit more than I want. So, I have to make a series of corrections to get what I want.

I give it an overall of 5.

--TURNING TARGET--

Not superlative there. I get the bank on there and my problem tends to -- my greatest error tends to be pitch, I think.

Overall rating I would up this to a 4 because ... I'm evaluating the level turn aspect only or am I evaluating the total configuration here?

For the wings level turn I would say 4. In other words, I feel like I was doing better on this maneuver than I was the last one with the wings level turn but overall I would, as far as accomplish the task, I would drop the rating back down to a 6, I believe.

The difference between the 4 and the 6 is because of the pitch problems I have in the 2G turn.

I noticed that if I try to bring anything else into my cross check, I bobble pretty bad on the pitch and once I bobble, it takes me a couple over-shoots to get it back on target. For example, if I check the range or whatever, if I were to look over my shoulder and check six or whatever, I would really be in trouble.

If anything, I would rather have it lighter.

RUNS 2038-2040 Pilot 22, 2"RP, 7lb BO, 60lb/g, WLT

--FAST LEVEL TARGET--

I would like to see less breakout force than that. I think I would like that. I'm not going to be so positive this time until I see it. I think I would be happier with less force. Displacement was fine -- no harmony problems. Sensitivity -- I don't think sensitivity is a problem. Overall I would give the test a 5.

--TURNING TARGET--

Forces -- I didn't notice the -- before, I remarked on the forces being too high -- I didn't make an observation of that this time so in other words, I thought they were about right. Harmony -- I guess I felt like the harmony was pretty good. I would guess that if you looked at my errors, it would be the same vertical and horizontal, I would think about equally spaced so that to me that might say to use as an indicator to harmony -- it's pretty good.

Unless you make this out to be more accurate with one hand or with my hand than my foot or something.

One thing we haven't talked about is roll authority and things like that. I assume those are constant for all maneuvers.

I'd give that another 5. I think it's probably better than the last controller, but I'm not convinced it's a 4. I'm going to stay with 5.

You know, there is a little bit of a conflict in here because when you... If you're giving me a specific task to do, then I should be really concentrating on that task -- you know, where I'm trying to stay within 5 mils of a certain amount of time.

Because in other words, if I'm going after a Cooper-Harper rating, then I'm going to do different things -- I'm going to run it out to the left wing tip and bring it back to the center and then try to shoot the top of the elevator and go down the bottom. If I'm really trying to give the best score that I can, then I don't do those kind of things. I lose a little bit in the comments I can make.

<u>RUNS 2041-2042</u> Pilot 22, 2"RP, 7lb BO, 20lb/g, WLT

--FAST LEVEL TARGET--

I would say that that was too sensitive.

Have a little trouble there talking about authority and sensitivity. I suspect it's just the sensitivity, authority was not too excessive. I noticed myself a couple of times generating a little bit of roll which is kind of interesting since I'm sure that's just my hand malfunctioning on me.

I would say the major characteristic there was too much sensitivity and as a result, I think it degraded my ability there to check the target. Displacement -- I'm not very sensitive to that. forces -- it's kind of hard to separate that from sensitivity but if the forces were greater, I wouldn't have thought it was so sensitive. Overall, my impression was that it was too sensitive. 6.

--TURNING TARGET--

I get complacent about range when I go from the level turn to the 2G turn.

I don't know the cause of my initial problems there but obviously, when I rolled in initially, I had trouble matching his bank and getting the pipper on target there. It took me a couple of big overshoots to do that and exactly the cause -- I don't know. I would give this another 6. Initially, I would say a 7, but then toward the last, a 5. In other words, gross tracking, I had trouble with. Fine tracking, once I got close, it seemed to work out pretty good.

Overall, a 6.

<u>RUNS 2043-2044</u> Pilot 22, 2"RP, 7lb BO, 40lb/g, WLT

--FAST LEVEL TARGET--

On that one, I noticed the control forces and I've seen better performance in the past so I'm going to give it a low 5 here. It was not bad.

--TURNING TARGET--

This is really getting screwball. I was pretty happy with that pass. I would have to say a 4. I don't know if you picked up my comment there or not, but during the roll in that time, I didn't use any rudder pedal until I was very close. The gross task was all sidestick control and then the only one I got within maybe 5 mils or 8 mils was when I start playing with the level turn.

I don't think I've been doing that before.

<u>RUNS 2045-2048</u> Pilot 22, 2"RP, 4lb BO, 40lb/g, WLT

--FAST LEVEL TARGET--

No comments on harmony. Displacement of forces felt natural. If I'd say anything about force, I'd say that I was aware of it. Overall rating I would give it 3. I don't know if that's justified or not. I just went crazy.

--TURNING TARGET--

I felt pretty good about it.

I think that I'm going to give it a 3. I think it seemed to work pretty well. The one concern that I have is that I don't feel like I was using the controller that much -- the rudder pedals -- and you have a better guess at that than I.

I kind of get the feeling I'm cheating or something here.

RUNS 2049-2051 Pilot 22, 2"RP, 10lb BO, 40lb/g, WLT

--FAST LEVEL TARGET--

I kind of wish I hadn't given that last task a 3. I don't think there's a significant difference between this but I think that rating was inflated relative to what I've been giving earlier.

I'm trying to decide, of these two, which one I like the better. I'll tell you what -- let me do it again.

Okay, I've picked 4. A couple of excursions in there which I felt inadequate to control.

--TURNING TARGET--

I think I'll give it a big 3 there.

I felt like the gross acquisition went pretty well, rolling in the bank angle and all that. I didn't feel like I had any real big excursions during the fine tracking phase. Sometimes I was out half a wing length but I never got the full wing length tip excursions that I recall.

RUN 2052 Pilot 22, 2"RP, 15lb BO, 40lb/g, WLT

--FAST LEVEL TARGET--

Right in between the 3 and the 4 that I've been giving here lately. I don't think I could distinguish it from the last three -- I'll go with a 3. The last three controllers are integrated in my mind.

RUN 2053 Pilot 22, 2"RP, 20lb BO, 40lb/g, WLT

--FAST LEVEL TARGET--

Just the same old 3.

RUNS 2054-2055 Pilot 22, TGSSC, .48in-lb DB, 24in-lb/g, WLT

--LEVEL TARGET--

I killed it.

Easy target there. I think I'm not as good with this controller at putting in a correction and nulling out the error and then holding it. I tend to kind of oscillate a little bit. I'll put in a correction, null out that correction, then I'll release it subconsciously. In other words, when I have to hold a deflection in on the sidestick, it doesn't seem as easy to hold a fixed sidestick or a twist position as it does on the rudder pedals.

Displacements and all that -- no problem. I think harmony seems perfect. Sensitivity is good. Authority -- plenty of authority for the test. Overall, I would rate this a 3.

--TURNING TARGET--

I find it really hurts my accuracy to look over there and check the range.

As far as comments, I think comments would be the same that I made for the last one.

Except in this case, I might say that I felt that I had a little more trouble with sensitivity and I would drop the rating down to a 4.

More sensitive. Let me see if I can verbalize here.

I guess the only other comment here is that I was making a conscious effort that that time to if I was not matching his bank, roll, I was banking and correct that. I was treating that as part of the task in which the bank angle was down. I think you can probably see from the twist deflection there or whatever.

RUNS 2056-2057 Pilot 22, TGSSC, .48in-lb DB, 12in-lb/g, WLT

--LEVEL TARGET--

It seems like I'm unable to put in the right amount of correction I need. I just about always overshoot. And I would say that it's oscillating about the target. I never really lock on. It seems like I'm always just kind of sashaying back and forth.

Do you know something? I don't think it's just this controller. I think it was true of the last one too and you know that could say that really what we're seeing on the data, the low amount of hits inside of 5 is valid. In other words, okay I'm always passing my, when I hit the target, I'm passing through it. I never lock onto it within a 5 mil. Actually, I'm always just keeping it close but never really locking onto it.

You're going to love this because the score was great. Rate that a 4. I felt like degraded performance over the last one where I did a level target.

--TURNING TARGET--

Unable to make pure inputs. I'm not even sure that makes sense, but what I mean is if I am not matched up at the bank angle and I roll to match this bank angle, then in the process of correcting that, I introduce an error in lateral, cross-track or whatever and I'm not able to anticipate that. So if I'm not wings level when I roll to match this bank, then I react to be in cross-track error after the roll to match this bank angle is complete.

Ideally, that would happen simultaneously, so let's say that that's a little bit of overload on the wrist or something like that. One thing, I don't know if you noticed this before or not -- I had more trouble with this in the first runs than I have

lately but in the first runs, I several times released the trigger. About three times in one of the runs - I should have mentioned that earlier. Just because I was putting so much other stuff into the stick or the side stick here, that I kind of let my finger relax.

I would give that a 4 overall.

RUNS 2058-2059 Pilot 22, TGSSC, .48in-lb DB, 36in-lb/g, WLT

--LEVEL TARGET--

I don't know if I'm getting tired or what -- I noticed twist grip force that time. I would give it a 3. That's my only comment on that.

I was going to ask you if that force idea was fatigue or not. That's not fair at this point.

--TURNING TARGET--

I think my hand is getting tired or it's higher force gradient and I would give that one a 4. I did something -- I cheated on that one. I wasn't so conscientious about trying to match this bank angle so I would use the controller to keep the pipper on target.

I don't want to say it but the bottom line is obviously, since I noticed that force, I thought it was too high.

RUNS 2060-2061 Pilot 22, TGSSC, 2.7in-lb DB, 24in-lb/g, WLT

--LEVEL TARGET--

I felt good about that. I'll give it an overall 3.

I was going to make a statement that said that when the target reversed turn on me, that I had trouble reacting to that but I really think that was prejudice because you mentioned that you changed the deadband.

Well here is what I was going to say. I was going to say that I have trouble reversing. When the target reversed, I had trouble reversing with that overshoot on that but I really think that's a fair observation because I think it's true of all the runs. I don't really think it's any worse or any better on this one. I'd give it an overall 3.

--TURNING TARGET--

I was never able to lock on the tailpipe. I always just passed through it. You know -- the corrections -- I don't think the deviations were that great -- the absolute value of the deviations but I never could really stop it on target for whatever

reason so the comment I made earlier about passing through the target, I think this is the worst example of passing through the aim point so far. I would say 5.

I think you can see what I'm talking about there. I go out to 6 mils and then I say I'm off again, and I say let me correct and I go zing through the target to a negative 6.

RUNS 2062-2063 Pilot 22, TGSSC, 4.8in-lb DB, 24in-lb/g, WLT

--LEVEL TARGET--

I'll give it a 3 -- and once again I am noticing stick force here. I seem to have less overshoots on my corrections on that run so I would expect a normal kind of inside 5 mils. I would say force is the only predominant characteristic I noticed as excessive.

--TURNING TARGET--

I'm not able to tell you why but I had about 6 big excursions and unable to tell you exactly what I think caused that. I thought it was an unusual number.

RUNS 2064-2066 Pilot 22, TGSSC, .48in-lb DB, 24in-lb/g, WLT

--LEVEL TARGET--

Real good. 3.

Stick force I would like to see lower but it seems like it maybe was not as high as it was a couple of the runs where I marked this too high. I seem to not be doing all the passing through the target type things you know, I was able to maintain the pipper on the target I think pretty successfully.

--TURNING TARGET--

Here is what I think it did. About half way through the run there, I kind of stopped using the twist so much and I believe my accuracy improved at about the same point when I stopped using the twist and I just kind of tried to stay conventional side stick. Now that doesn't tell you much about this particular configuration but it's kind of an interesting thing. I don't know if I can confirm that or not.

4. No significant comments here. I feel stick force again. I guess I really don't have anything to say except high stick force.

RUNS 2067-2068 Pilot 21, TGSSC, .48in-lb DB, 36in-lb/g, WLT

--LEVEL TARGET--

Comments lost. The run log indicates the pilot gave a Cooper-Harper rating of 3.

--TURNING TARGET--

The only critical comment of that one, it just takes a little bit more forearm. Once I got my forearm built up, that one would have been alright.

Let's give it -- what did I say, a 3 1/2 -- 3 or 4, desired performance requires moderate -- let's give that one a 3, too. It wasn't bad. The feel was good, the sensitivity, authority, response.

<u>RUNS 2069-2071</u> Pilot 21, TGSSC, .48in-lb DB, 12in-lb/g, WLT

--LEVEL TARGET--

I liked that one.

This one and the other level one I did were about the same, but I like this one better even, I don't know why. Let's give it a 3. It could be a 2. If we want to change let's call it a 2. That was better than the one we did before.

What causes the indecision is I think it's just a combination of twisting and I'd say it's just a different mode. It's not -- the forces and everything and the authority and the response are all good. I really like that one.

What I need -- I need a button for my power.

Like a couple clicks would give me a percent, because in these turns it only takes about 4%.

Yeah, a fine power correction.

--TURNING TARGET--

I liked that one. I probably didn't do too good, it's a little bit loose, but I like that.

When we did this thing before, did we talk about the shape of the controller here as far as for twist?

I don't think it's optimum for twisting. I'm not sure, because I don't know, maybe something a little fatter. My hand is wrapped around it, not real comfortable. I'll try a different way.

I'll give this one a 4 because I think it is too loose, but I believe with a couple more tries, I had to get it much too tight or more stiff. I like it, but it's taking me a little bit of effort to keep it steady. I think if I practice a little bit, that's whatever you have in there now, I think that's what they'd want it like. But let's call it a 4, because it is a little bit loose.

It takes a little bit of concentration.

I think the shape of the controller for twisting would make a big difference.

RUNS 2072-2073 Pilot 21, TGSSC, .48in-lb DB, 24in-lb/g, WLT

--LEVEL TARGET--

Maybe our task is too easy. If we thought about doing it with the feet, I'd rather do it with this on this task. That's not hard at all.

I'm not convinced yet in the turn.

I'd give that one a high one -- let's call that one a 2. That was easy and has a nice feel. If the score's not high on that one, then something's wrong, because that one we hardly got off of it at all.

--TURNING TARGET--

It does for me take a little more concentration. My concentration of thinking what it means to twist that thing. Like when it got away there, I wasn't -- instinctively I wasn't sure exactly how to get back.

I knew I could bank over and pull it I'd be back on, but I was trying to combine the twist with that and it confused me. It's confusing to me.

Also, when it got away I'm not really sure why I let it get away from me.

Let's give that -- it's almost a 3, but let's say a 4 because I know what's bothering me a little bit. It's the amount of muscle I've got to put in my wrist and I'm starting to feel that and I'm not getting tired or anything, but it's not bad. It's not where I'd say it wasn't a little bit annoying. Maybe that's what happened to me on the other one. I must have just got tired and relaxed for a second or maybe I was looking at something else.

I might have been holding a twist while being overbanked, whether I intended to or not. Maybe that's why it's a little hard for me. Just twisting in my arm -- it doesn't really come naturally yet. I think it will.

I'd be willing to go fly anything that we've tried today.

RUNS 2074-2075 Pilot 21, TGSSC, .48in-lb DB, 12in-lb/g, WLT

--LEVEL TARGET--

Again, I would give that one a high rating. Why don't we say 2.

I couldn't tell any differences in that one. It just seemed like the target wasn't that much of a challenge. Of the ones we've done, I bet that one should come out high on the 5 mils.

--TURNING TARGET--

I liked that one. Let's give that one a 3. I was working harder than I needed to. I think that one was an easy one to do and if I'd have relaxed just a little bit on my wrist that one would have been better. That's the best turning one I think we've done.

I think I know how I'd design this controller now. I think ridges or something that fit between the slots in my fingers on the right and then something that came out on the left to put my...and then I'd have a little leverage and torque or twist on it.

You know when I was pushing on the rudders, when we loosened it up you can -- I like it like that, but to keep it from overshooting you can change the pressures on either foot, so if I had something on each side where I could work my thumb and the right part of my hand, I could compensate. It would give me, it would be easy to aim that thing.

RUNS 2076-2077 Pilot 21, TGSSC, 2.7in-lb DB, 12in-lb/g, WLT

--LEVEL TARGET--

Why don't we call that one -- we gave on other one a 2, let's give that one a 2. There wasn't anything about that one that bothered me.

Let's give that one a good grade. Give it a 2.

I'm not so sure if I had the same controller in each hand, I may be able to fine tune it, I don't know.

--TURNING TARGET--

I thought that was a good one. I liked it.

I'd give it a 3 and that one was really nice. I could have done better if I'd have tried a little bit harder I think.

This will be good for tennis players or whatever. It's good for the form here. Must use some muscles torquing the wrist.

RUNS 2078-2079 Pilot 21, TGSSC, 4.8in-lb DB, 12in-lb/g, WLT

--LEVEL TARGET--

Higher breakout forces in that one or? That wasn't a bad one, but that wasn't one of the best ones. Why don't we give that one a 3.

Well it felt like I didn't get the response that I wanted right away.

I guess we could call it a lag.

I wasn't working very hard on that one. It may have caused me to put the bank in when I wasn't getting the yaw that I expected.

--TURNING TARGET--

That was a good one. I probably didn't score very well, but I'd give that one a 3. I think I got tired on that. We can do that one again if you want. I think I could do better.

Let's give it a 3. I like that one.

I didn't pull the trigger as much as normal that time, because I was off of it more.

I think I got lazy on that one.

RUNS 2080-2081 Pilot 21, TGSSC, 7.5in-lb DB, 12in-lb/g, WLT

--LEVEL TARGET--

I don't like this at all.

Why don't we give that one a 6. There's too much force and it's not sensitive enough and it's just not very good. I noticed on that one it required too much force to twist and that really affects everything else. It wouldn't go where you wanted it to go and then it would stop and then you'd try to twist it again. I didn't like that one.

Your maneuvers weren't drastic enough there so that you couldn't stay on.

--TURNING TARGET--

I'd give that one -- what did we give the last one a 6? I'd give it the same. It takes too much to get it going and then it's underdamped when it does go and you can't stop it and it wallows all over.

RUNS 2082-2084 Pilot 22, 2"RP, 7lb BO, 60lb/g, WLT

--LEVEL TARGET--

4 -- make that a 3. Force, I'd like to see the force reduced. I felt like it was good. It seems like I had trouble when I passed through the neutral point. It was during a roll by the target when I was trying to correct some of the right drift to a left drift I would have trouble -- I could stop to the level right

turn and I could neutralize it. Then when I started back to the left, I couldn't build that up smoothly with the target. Every time I would lead it then I'd have to take some input out to let the target catch up with me.

I think the force was the biggest thing on this.

--TURNING TARGET--

On that run most of my errors were pitch. I seemed to be doing a real good job of lateral tracking there. But, I was having a lot of pitch bobbling. I didn't notice the force that time. It didn't bother me.

I would have to go with a 3 on the pedals and I don't know why I had so much trouble with the pitch. I assume this is where we've used it all along.

RUNS 2085-2087 Pilot 22, 2"RP, 7lb BO, 20lb/g, WLT

--LEVEL TARGET--

I want to rate it. This is going to be an interesting rating. I'd better drop to a 4 and I think we compromised too much on the rudder pedal force there. I think I was overcontrolling, because of lack of force. That could have something I couldn't probably adjust to. I didn't adjust well, going from the last one which is the reason.

As long as you aren't too worried about the scores you might put a comment down there. The scores are thrown off a little bit by the two jumps. I'd give that a 3. I think I'm able to compensate better there by now than overcontrolling like I was before. Just bobbled a bit more I suspect reduced forces and I would say though that now I feel a little bit of a harmony problem. In other words, the rudder pedals are too light in relationship to the stick. An overall 3.

--TURNING TARGET--

2 mils would be tough. Pretty nice roll there. Not much rudder pedal used. Don't really need it. It's not because I'm being lazy or anything. I'm bobbing a little bit of pitch the targets. It's hardly around 5 mil.

Really good pedals. I liked the harmony there. Sensitivity and everything, it seemed like my biggest problem -- my pitch problems were a couple time greater than my lateral problems.

3. High 3.

RUNS 2088-2089 Pilot 22, 2"RP, 7lb BO, 40lb/g, WLT

--LEVEL TARGET--

Good. Had one excursion off on the right wing there, other than that it was pretty good. I'm going to have to go with a big 2 there I think. I don't really have any negative comments. I guess we could make a positive comment sometime though.

I don't have anything to say -- worked pretty good -- pretty good.

--TURNING TARGET--

Comments lost. Notes from the run log indicate the pilot gave a rating of 2.

RUNS 2090-2091 Pilot 22, 2"RP, 4lb BO, 40lb/g, WLT

The exact pilot comments were lost. The run log indicates that the pilot recognized the existence of a problem but was unsure as to what its nature was. The pilot gave both the level and turning tasks pilot ratings of 3.

RUNS 2092-2093 Pilot 22, 2"RP, 15lb BO, 40lb/g, WLT

Exact comments lost. Notes from the run log show that the pilot commented on good control harmony and gave the level target task a rating of 3 and the turning target task a rating of 2.

RUNS 2094-2097 Pilot 22, 2"RP, 1.5lb BO, 40lb/g, WLT,
Note: breakout due to friction only

--LEVEL TARGET--

Deadband problems. When I'm reversing I establish a rate and then as I pass through the neutral point, the rate dies away and I keep moving the rudder pedals at the same deflection rate and I don't get anything. Don't get anything until I increase the rate and then it finally takes hold and I've got too much.

Would it make sense if I said force instead of deflection then? This guy -- he's changing his roll-in from a left bank to a right bank at the same rate so I've got a constant force applied and the force takes me into the deadband and do I need to bump the force up to get through it or something?

I really can't say anything constructive. Let's just give it a 2.

That's an interesting experiment doing it three times.

Real good. No problems a 2. I wasn't using much pedal; I don't think it was really needed. I don't think you'll see too much sidestick inputs either. I hope I'm not lying.

RUNS 2098-2099 Pilot 22, 2"RP, 20lb BO, 40lb/g, WLT

--LEVEL TARGET--

Wow, was that stiff.

Too stiff. The only problem. 4. That other one I complained about being stiff -- I said boy I can live with this one, I think I'd want to fix it.

--TURNING TARGET--

I haven't used the pedals yet.

Those controllers just worked great that time. Both times we used it.

I didn't use any rudder but one or two times there. (No rating given.)

RUNS 2100-2101 Pilot 22, TBC, .05lb DB, 5lb/g, WLT

--LEVEL TARGET--

I like the sensitivity. Didn't have any problems with authority. I felt like the harmony was good. I would say my biggest problem I had was overcontrolling. The controlling is more like the twist grip than the rudder pedals where you sit there and you continuously put inputs in because you're not able to put inputs in as accurate as you would like so you tend to overshoot a little bit right -- overshoot the left -- overshoot the right. You change the amount of error you're putting in. I don't think I'd buy one of these without fixing it. I'd give it a 5.

--TURNING TARGET--

Another 5.

I was really unhappy with yaw error or lateral axis error. I would say in that case I felt over-sensitive. The controller was over-sensitive. I seemed to have plenty of authority but have a lot of lateral errors.

Better than I was doing with the twist grip initially.

RUNS 2102-2104 Pilot 22, TBC, .05lb DB, 1.25lb/g, WLT

--LEVEL TARGET--

Yuck. Way too sensitive. So sensitive that there was a harmony problem here with 2 inch motion in the lateral axis and I would give this a 6.

--TURNING TARGET--

Good authority. Wow, what an error. What caused that? I was trying to match my bank roll and trying to take out the level turn and put in the bank at the same time. It didn't work too good. Oh, this is a mess.

I think that was the worst I've ever done. Let's try that again.

I've been so busy fighting this thing I haven't even thought about range.

7. I can still control the airplane. The same problems have been here. Here is the major problem I noted. I fI get a mismatch of bank angle, I'm unable to match his bank angle and pick out whatever level turn authority I have in without having a gross error in target. I'll have 10 or 12 mil error result if I have a 20 degree bank angle mismatched, or something like that and I try to match up his bank angle. If I think about concentrating on everything, it's still going to...

Well, let's see. I guess I'd say it's a coordination problem. If I've -- I don't have enough bank. Let's say I've got 40 degrees and I need 60 degrees to bank so I start to roll into bank and when I do that, even I am consciously trying to take out the level turn by rolling out, the bank causes me to deviate off the target. I'm unable to respond with my thumb, to control that. Basically, it just shoots off into space and then some time after that, I react, which there is a time delay there and it's such a delay to cause a big error.

Also, I don't like holding my thumb on there. The feel of my thumb and my "trigger" finger pressing against each other is a little bit unnatural; you know, it's more natural to use the tip of your thumb. I guess I just found out something. I'm using the first joint of my thumb to control it with. Let me see if I can do it different. If I can use the end of my thumb.

<u>RUNS 2105-2106</u> Pilot 22, TBC, .051b DB, 2.51b/g, WLT

--LEVEL TARGET--

Just like the old days. Lost some good bullets there.

That was the end of my thumb. Instead of using the first joint, I used the tip of it. I'll give that a 3.

Harmony is good, sensitivity is good. The only reason I didn't give it a higher grade is just that I wasn't as satisfied with the accuracy as I would like to be, but don't have any specific problems with it, but it seemed like the end of the thumb might work out better. I don't know what you've done to the characteristics here.

--TURNING TARGET--

Okay. 4 on that. I'm having that problem with mismatch of bank. Taking the mismatch of the bank out causes an error. It's not as big as it was last time. I'll give it an overall 4. Harmony, sensitivity and all that I thought were pretty good.

Okay. Just because you want me to match this bank, if I'm not close to the pipper, then the first thing I do is get the aim point lined up and then, if I notice that I've got a mismatch of bank, I'll try to go after correcting that bank but the first part is getting the pipper on target, second, is bank. Do you want me to break down how I attack an error?

It depends on what the target is doing. Let me talk about the level turn target. The first thing I look for is an azimuth deviation and I go after that with the thumb controller. The second part is pitch. Okay, for a 2G target, the first thing I go after is bank. My first priority is to match his -- go after him with bank because if he's rolling away from me -- going off to the right -- I'll be rolling right and going after him with the right turn but the first part is to bank, I think, but it's not too far apart and then I'm making pitch corrections a third after those two.

<u>RUNS 2107-2108</u> Pilot 22, TBC, .05lb DB, 5lb/g, WLT

--LEVEL TARGET--

That wasn't too bad. I would go back and jump on a 3 for that one. I think I might like a little bit less force. I'm not absolutely certain about that conclusion but reasonably happy with that. I did see a couple of excursions off to the right wing which I don't have an explanation of exactly why that ocurred.

--TURNING TARGET--

That time I led with the level turn and bank was secondary priority.

I'll give that a 3 and I'd like to see a little bit less force. Sensitivity is good and all that stuff.

<u>RUNS 2109-2110</u> Pilot 22, TBC, .05lb DB, 3.33lb/g, WLT

--LEVEL TARGET--

3. No problems except for accuracy, which is the reason I wouldn't give it a 2 or something like that.

The only problem I have with that is I want to push up on the button to use it for pitch.

The way I grip it looks kind of strange.

--TURNING TARGET--

Okay. There's a bank angle mismatch and I'm going to try to match it up. Okay. I'm rolling right and trying the left thumb at the same time but it doesn't work out too good, and I go zigging off the target. So, if I'm in here I can make some corrections but basically, they're kind of uncoordinated corrections. There is the bank angle mismatch.

I'm unable to pinpoint exactly what the cause of the degradation accuracy is but that's the reason from dropping from a 3 to a 4.

RUNS 2111-2113 Pilot 22, TBC, .5lb DB, 3.33lb/g, WLT

--LEVEL TARGET--

I just get a wild correction in.

Occurred two or three times. Maybe it's the the seam in my glove or what. I'll see if it occurs again.

I didn't notice I didn't have motion that time.

I understand what you are saying because I think sometimes I react to the feel -- feel myself being kicked from side to side and I say, hey, you are overcontrolling.

I'd give it a 3. I can track pretty accurately, but every now and then I get one of those glitches in there, I can't tell you what happens.

I like the sensitivity.

--TURNING TARGET--

I think I did reasonably well in the turning task. I'll give that a 3 also. I find rolling in with that target difficult. I'm not sure the priority of what I said when I roll in is the same the last couple runs. I've noticed that I'm going after him with side force and sensing that I'm drifting, not keeping up with him, then I go with bank. It seems to be a more accurate description of what I'm doing.

I'm not sure if that's been true all along or if that's a change. I had trouble in that regime though.

RUNS 2114-2115 Pilot 22, TBC, 1.0lb DB, 3.33lb/g, WLT

--LEVEL TARGET--

Lot of zigzagging around when he reverses direction. When he reverses direction, it seems like I get a couple of overshoots in there. On other controllers I've been able to do it with 1 deviation off the target and get back on, this time I seemed to go off and I'll go after him and I go after and I go off overcorrect, I come back and two or three corrections, one screw-up in there.

Minimal compensation. 3.

--TURNING TARGET--

I corrected that bank problem that time without having a big glitch. A 4 for accuracy and I felt excessive force then.

RUNS 2116-2117 Pilot 21, TBC, .05lb DB, 5lb/g, WLT

--LEVEL TARGET--

I kind of like that. Let's give it a good 3. The only problem I had was when I got off the target was getting back on right away. It took me a little bit of time to see how much I had to move my thumb. Nothing annoying about that.

It wasn't too hard. Just couldn't tell how much movement of my thumb to get it back on. I kind of like that. It's not uncomfortable.

--TURNING TARGET--

I'd give that one a 3. I was using the tip of my thumb and using the same pressure to push with the thumb as I was pulling with the trigger. My thumb felt a little funny. I'll give that a 3.

It's in the knuckle, the way I've got my thumb bent. I'm using the tip of the thumb. I don't have any bad things to say, a 3.

It appears it's not too difficult to keep it on the target with the thumb.

RUNS 2118-2120 Pilot 21, TBC, .05lb DB, 1.25lb/g, WLT

--LEVEL TARGET--

I like that, you are giving me too many good things to evaluate. I'm going to like them all. Let's do that one again. I don't like that one too much but I think I can do better. My overshooting...for some reason I just want to kick it all over the place. I know why, because with the feet and twisting I've got something to stop there, with the thumb, the thumb is used to putting inputs in one direction.

But even when you change the gradients with the feet I can control; with the thumb, I'm just -- with the feet I can work against each foot and even twisting I can work against the twist, but with my thumb when I put it in you are going to go that way. It's like a one-dimensional thumb with two-dimensional feet.

Okay, let's rate it. That's not good for the thumb, so why don't we say 5.

Okay, the feel is okay, the forces, it's the control sensitivity I guess. It's too sensitive. I'd like to switch to the rudder now. I bet in this condition with rudder it didn't bother me. In the response, I like it that it's so sensitive but with the thumb -- I'm pushing in one direction, the only way I could stop it...I need to be able to put in a little bit of right thumb at the same time and I can't do that.

I might try a different part of my thumb.

--TURNING TARGET--

Let's give that one a 5, too, and again, I can't -- it would be easier to keep swing through the target -- but I just can't hold it on the target. I don't mean to say can't, I can, but it's tough. It's easy to swing through the target, but I can't stop it on the target and hold it on the target.

<u>RUNS 2121-2122</u> Pilot 21, TBC, .05lb DB, 2.5lb/g, WLT

--LEVEL TARGET--

I'd give that one a 3 and that was fairly easy. I changed the position of my thumb. I don't think it made any difference. That one was fairly pleasant.

Well, that time I shoved my thumb up where it was in the beginning. Like you said, instead of using the tip.

So far I like this mode better than the twist. It seems easier once you get used to it.

--TURNING TARGET--

Let's give that one a 3. I really like that one. It took me a little while to get used to it, but I liked it. It's not too sensitive. It's sensitive enough where it doesn't take too much thumb movement to get the response you want. It's not overly sensitive where it overshoots.

In the beginning I lost it and toward the end I was getting back on it.

<u>RUNS 2123-2124</u> Pilot 21, TBC, .05lb DB, 3.33lb/g, WLT

--LEVEL TARGET--

More natural than twisting the wrist, and it's probably because looking through the reticle or the sight there it's like I got direct control the that thing with my thumb. It seems more natural than twisting the wrist. That was good. What's the highest I've given -- a 3. Why don't we give that one a 2 1/2? One thing I noticed and I don't know if it's got anything to do with the thumb wheel there, but when we start out and I push it over to get on its tail, it comes straight down.

Let's rate that one the highest, 2.

--TURNING TARGET--

Now that's one I can give a strong 2. That one was really comfortable. I probably screwed it up a little bit. I purposely got off a little bit and got right back on and it was really easy. Another thing I noticed on the trigger -- I was trying harder to

stay on it in the beginning, but when you let off that trigger, that affected my thumb. So maybe I held the trigger down a little bit more, but every time I let off the trigger, I got -- my index finger and my thumb must be hooked together here.

But it's so nice using the thumb to stay on the target. It's almost I don't need the trigger, just shoot the bullets and I'll just keep it in there with the thumb.

Maybe for the thumb the trigger should be put on the left hand. I'm using the thumb now all the time up near the first knuckle. I think that's more comfortable.

RUNS 2125-2127 Pilot 21, TBC, .5lb DB, 3.33lb/g, WLT

--LEVEL TARGET--

Let's give that one a 2. We'll buy that one. That's really fun with the thumb.

Like shooting fish in a barrel.

--TURNING TARGET--

Great! A 2 without any hesitating. There is something about the relationship of pushing with the thumb and pulling with the trigger that those two fingers are working against each other that makes it easier. It's easy to make motions with the thumb by the fact I'm clamping down on the trigger.

When we were doing with the pedal, seems like I commented in the turns it was harder. In the turns it's really easier.

RUNS 2128-2129 Pilot 21, TBC, 1.0lb DB, 3.33lb/g, WLT

--LEVEL TARGET--

If I hadn't seen the one before, I probably would have liked this one. Why don't we give that a 3. Just because it wasn't as easy as the one before. I'm not quite sure, it felt like there was a lag when I overshot or it was less sensitive. It wasn't a bad one, but the one we did before was better.

--TURNING TARGET--

I like it. Let's give that one a 3. In the turn it is really nice. Same comments.

Just from sitting here handling the thumb button, this is the best controller yet.

Just flying the thumb button the handling of it. Yes, I like this better than the pedals.

When I'm flying around here my thumb is not moving very much.

RUNS 2130-2131 Pilot 21, TBC, 1.5lb DB, 3.33lb/g, WLT

--LEVEL TARGET--

Okay. This is sort of silly, but its too much force to get it going and once it gets going it overshoots a little bit, it feels like it does. But the force to get it going is wearing my thumb out.

It wasn't bad, and it's not difficult, let's give it a 4. It just took too much oomph.

--TURNING TARGET--

Really noticeable better in turns, for all the configurations.

Let's give that one a 4, too. It's probably just preference. That one I compensated by, I was always moving my thumb, but the movements I got on the screen -- they weren't translated up there, but it kept its center so I could continuously move my thumb and keep it in there. I don't know if I like that or not, so let's give it a 4. Remember when we first did it? The condition you had in there -- I moved my thumb and I couldn't stop it. Well this time I could keep my thumb moving and keep it centered.

RUNS 2132-2133 Pilot 21, 1"RP, 7lb BO, 40lb/g, WLT

--LEVEL TARGET--

Why don't we give it a 2. There wasn't anything objectionable.

I like the thumb button better. In fact, I flew with my finger on the thumb button all the time. I'm educating my thumb.

--TURNING TARGET--

Pretty good. I'd give that one a 2, too.

Little bit of oscillation in pitch, but it wasn't bad. At times I got off this because I was looking at the RPM indicator. But it wasn't hard to keep it on. I guess you get better at this.

But it was easy.

RUNS 2134-2135 Pilot 21, 1"RP, 7lb BO, 20lb/g, WLT

--LEVEL TARGET--

How were you making it harder? I don't know any reason to give that one any less than the other one. Let's give that a 2, too.

It felt like it was a smaller gradient. Maybe it wasn't.

--TURNING TARGET--

I'd give that one a 2, too. Between the four runs in the turn I think I like the first one better because it didn't oscillate around so much. It's really fine here. They both are fine. Looking at these scales, I couldn't give it any different really. They're both good. I like them both. I almost think I like this last one better, but the other one was a little easier to hold.

I know I like my thumb on that thumb button.

RUNS 2136-2137 Pilot 21, 1"RP, 7lb BO, 60lb/g, WLT

--LEVEL TARGET--

Really tough, there's nothing wrong with that, but I like the lighter forces better. So just to make a difference I'd give that one a 3 because of the loads. But it's not harder to do, it's just I like the feel on the other one's better.

--TURNING TARGET--

Let's give that one a 2. Because in the turn it is easier to hold. We should have -- if we went back to the one turn before, we should have given that one a 3, for the same reason, level on a 2. It's easier to hold in a turn.

In the turn it is easier.

I like the lighter forces but it was easier to hold in a turn.

RUNS 2138-2139 Pilot 21, 1"RP, 10lb BO, 20lb/g, WLT

--LEVEL TARGET--

Pretty good. That's probably not the best of them, I like it because it's so sensitive. But it's probably not the best. I'd still give it a -- I don't know, I've kind of lost track.

It's a 3. Just because it felt like - if you are varying the breakout -- it felt like it would overshoot a little bit. Just a hair. It's not bad. But I bet for the average bear it would annoy you. But I like it. I'll give it a 3.

They are all getting really to feel natural.

--TURNING TARGET--

Give that one a 3. Just because it was a little more difficult to hold. It was a little harder to catch up with at first, but once you got on it, it wasn't hard to stay in there.

RUNS 2140-2141 Pilot 21, 1"RP, 4lb BO, 20lb/g, WLT

--LEVEL TARGET--

Okay, why don't we give that one a 4. That one was too loose, I overshot. Took quite a bit of concentration to keep it on the point.

--TURNING TARGET--

Looking good. We're getting a bumpy ride. Why don't we give that one a 3. It was better than the level, if those were the same conditions.

We had a little simulator inputs, too. Didn't affect staying on target. They were periodic and they would bump, bump, bump.

I wonder if I can do a roll and stay on the target.

RUNS 2142-2143 Pilot 21, 1"RP, 15lb BO, 20lb/g, WLT

--LEVEL TARGET--

Let's give that one a 4. It's easy enough, I can do it, but it's annoying. It oscillates. You get it going and then it goes past...I can work my feet though and stop it pretty much. But I don't like it as well. I give it a 4.

--TURNING TARGET--

Let's give that one a 4, too. When I'm using these 4's these are bad compared to the good ones. And again it's just more difficult to keep it on the target, you overshoot to stop it from overshooting, although it's not hard. And our simulator is starting to perk again. Seems like it got heated up awful fast today.

Let's give a 4 on that one, that was definitely harder. I think on my next one I would have done better though, because my hand motions were kind of eratic -- not eratic, but at the end there I was getting it down a little bit closer.

RUNS 2144-2145 Pilot 21, Conventional 1"RP

--LEVEL TARGET--

It's more fun with motion too. It's a little bit more of a challenge with the motion.

The motion definitely adds something to it.

Remainder of comments lost. Notes from run log indicate the pilot found the task very easy and gave a Cooper-Harper rating of 2.

--TURNING TARGET--

Exact comments lost. Notes from run log indicate that the pilot flew fixed-base, and found the task definitely harder than the level target. Cooper-Harper 4.

RUNS 2146-2148 Pilot 22, TGSSC, .48in-lb DB, 24in-lb/g, WLT, Fixed-Base

--LEVEL TARGET--

I felt like the forces were too high, not real bad -- a little bit, not really if you force it, but it's slightly heavy we'll say. Displacements are good because of the...when I perceived was a little bit too high a force I felt the harmony was a little bit out. But I need to qualify that remark by saying...of course we are dealing with a level turn here where you don't use much bank input and pitch, and overall I would give that controller a 3.

--TURNING TARGET--

Really nice. Give it a 2. Overall the forces were perhaps slightly high, but less significant than with the left turn. So it must be very slightly high.

I don't really have any derogatory comments.

RUNS 2149-2150 Pilot 22, TGSSC, .48in-lb DB, 12in-lb/g, WLT, Fixed-Base

--LEVEL TARGET--

I'll give that one a 3 also, but in that run, I started noticing the overcontrolling. It was bang, bang. It was open, stop, stop. But I was going from left to right passing through the target. Not quite as able. It wasn't real bad but I wasn't really able to stop on the target like I was with the earlier configurations. But I don't have any complaints about force this time.

--TURNING TARGET--

3 overall and don't really have any important comments to make. Seems like my deviations from the target were about equal, both in pitch and terms of lateral. So it kind of leads me to the conclusion that -- is good and maybe it's not a control limitation so much right here down by the spot limitation.

Less trouble with it than with the level target. I didn't notice the passing back and forth but probably my pitch errors increased to the same magnitude now as my crosstrack errors.

<u>RUNS 2151-2153</u> Pilot 22, TGSSC, .48in-lb DB, 36in-lb/g, WLT, Fixed-Base

--LEVEL TARGET--

I'll go a 3 again. And I had one of those big errors in here...I don't know exactly what caused it. I noticed force and I'll feel myself pushing on the stick. I'm not sure though if the force is really too high. I notice it...different motion and I don't know if it's good, bad or indifferent.

Harmony and sensitivity and everything seem to be alright.

--TURNING TARGET--

Give that one a 2. No comments.

<u>RUNS 2154-2155</u> Pilot 22, TGSSC, .48in-lb DB, 24in-lb/g, WLT, Fixed-Base

--LEVEL TARGET--

Give it a 2.

--TURNING TARGET--

2...maybe more force than I would like, really small difference. Too subtle to be really firm/convinced about.

<u>RUNS 2156-2157</u> Pilot 22, TGSSC, 2.7in-lb DB, 24in-lb/g, WLT, Fixed-Base

--LEVEL TARGET--

My accuracy degraded somewhat, beats me why.

I can't help you. I'm at a loss here. I didn't notice anything that annoyed me or made me want to comment about it. I just felt like the accuracy wasn't quite as good as it had been before. The controller accuracy, and the lateral axis and pitch up or anything else.

I think a 3.

--TURNING TARGET--

2...no real problems.

<u>RUNS 2158-2159</u> Pilot 22, TGSSC, 4.8in-lb DB, 24in-lb/g, WLT, Fixed-Base

--LEVEL TARGET--

I'll give that one a 2 -- a slight force perception, little bit of I noticed force that time, too high. Very slight. Worked pretty good though.

--TURNING TARGET--

I had a couple deviations in there but they all occurred when I was taking my eyes off to check speed or range and they tended to occur in pitch primarily so the correction I had to make was pitch more so than crosstrack. In other words, if I momentarily looked away and had a great big crosstrack error then I would say I was putting a lot of attention into that...a slight additional work load could cause that to be really bad. But I think the major error was in pitch as a result of negligence and not in crosstrack error. I'll give it a 2.

RUNS 2160-2162 Pilot 22, TGSSC, 7.2in-lb DB, 24in-lb/g, WLT, Fixed-Base

--LEVEL TARGET--

Very slightly high force -- overall 2.

--TURNING TARGET--

I'm having troubles here and that's not helping a bit. They are all melding together. I'd give that a 2, and if you asked me to tell you the difference between that one and the one before, and the one before that, I would have a lot of trouble.

I really feel...it's just getting so close to working out so well, I really don't have anything significant to add.

RUNS 2163-2164 Pilot 22, TGSSC, .48in-lb DB, 24in-lb/g, WLT, Fixed-Base

--LEVEL TARGET--

As I said, I noticed I had lateral problems on that one and so the question is just whether I should call it a 2 or a 3. I did notice a tendency that was a deterioration from an earlier one where I was doing a couple mil lateral and I think I'd still need to say 2 though overall.

--TURNING TARGET--

Give it a 2.

Nothing I can...worth talking about.

RUNS 2165-2166 Pilot 21, TGSSC, .48in-lb DB, 36in-lb/g, WLT, Fixed-Base

--LEVEL TARGET--

I think it wasn't too hard, but I believe I'd give it a 3 because of it's -- it's tiring my arm out. My arm gets tired doing that

and it's a little bit difficult to keep it right on it. It oscillates back and forth and it's hard to take that out. So how about a 3? I think I stayed on pretty close most of the time.

And again I think when we use this grip, this grip -- I don't think its built for twisting motions, I think we could redesign it.

Harmony felt good.

--TURNING TARGET--

About the same level of difficulty, let's give it a 3. The reason -- or I got off the target there for a minute because I glanced at the cockpit and it just got off. It's really hard -- not hard, but it's not easy. The twisting motion is giving me a little bit of bobble in pitch.

What I did, I glanced at the RPM for a second and that's when I got off of it for a little bit.

The twist does seem more natural now than last time.

<u>RUNS 2167-2168</u> Pilot 21, TGSSC, .48in-lb DB, 12in-lb/g, WLT, Fixed-Base

--LEVEL TARGET--

Let's give that one a 2. The bank twisting motion -- it's the same thing as we said before. I guess it gets hard to twist it so I just naturally bank it and I've got to think about it. It just doesn't come naturally to twist it over there and when I try a little twist and it doesn't, I just bank it.

That one felt more sensitive and I like it like that. It felt like it took less force to control it.

Harmony and everything is still fine.

--TURNING TARGET--

Let's give that one the same. It's a little more difficult in the bank. Seems like the pitch and twist get kind of coupled there and I'm bobbling in pitch. It takes a lot of concentration to stop all that.

A 3. I don't know how we got 90° of bank. I know I was trying to concentrate on maintaining the air speed.

Maybe the hand takes the path of least resistance and it's easier to bank it as it is to twist it. I'm trying to twist...

RUNS 2169-2170 Pilot 21, TGSSC, .48in-lb DB, 24in-lb/g, WLT, Fixed-Base

--LEVEL TARGET--

Okay, now that's how I can see I was banking too much. It's just easier to bank it.

That would seem like the easiest one of the ones we've done today. It seemed like it didn't bobble around so much. So let's give that one a 2.

It is a little better harmony-wise. I seem to have enough authority for this test.

You don't need very much, not for that test.

--TURNING TARGET--

It was going real good until I got off and then I didn't have enough authority to get it back. Got off by a couple crosshairs and to get it right back it took a little bit extra. But until I got off, it was doing real good.

Let's give it the same as the level one -- 2. It was really easy till I got off and then it would get right back on it. It didn't -- I don't think I had enough authority.

I ended up using bank to bring it back.

RUNS 2171-2173 Pilot 21, TGSSC, 2.7in-lb DB, 24in-lb/g, WLT, Fixed-Base

--LEVEL TARGET--

The excursions are so small it's really hard to tell if it's good or bad. It's easy. Let's give it a 2.

The small excursions that the target is making are really easy to follow and I can't really feel the controller, you know I'm hardly even moving it. So if the deadband...if it's high I can't really tell it. It doesn't bother me, whatever it is.

You know that run would almost be a toss up between the thumb wheel and the pedals and the twist.

--TURNING TARGET--

Okay, that was the easiest one of all. I'd give that one a 2 and I don't have any negative comments on that. You ought to keep an eye on the airspeed too because I think it's directly proportional how easy it is to track that my speed stays on. Because the easier it is to track I start looking at other things, like

my airspeed and the RPM then roll off here to the left. Let's give that one a 2. I think it feels like it's easier in here without the motion. I might be imagining that but that's the way I feel.

RUNS 2174-2176 Pilot 21, TGSSC, 4.8in-lb DB, 24in-lb/g, WLT, Fixed-Base

--LEVEL TARGET--

I never got off of it, I don't know. I don't know how to rate that one. Let's call it another 2.

With that one it's really hard to tell what I'm doing, twisting or banking or what.

--TURNING TARGET--

I don't think it was bad, but one time I got off and it took me a little bit to get it back on.

I'd lower that one to a 3. In the effort I had to put into the twist I think it made me bobble and pitch, which kept me off of it a little more than before. Does that sound right? That's what it did. It was a little bit harder that time to keep it on all the time.

RUNS 2177-2179 Pilot 21, TGSSC, 7.5in-lb DB, 24in-lb/g, WLT, Fixed-Base

--LEVEL TARGET--

Why don't we give this one a 3, and it just felt like the force on my hand was too high to get started, and it was tiring. It wasn't too hard to -- once I was on it -- to stay on, but if I got off, I'd lag getting back on. My hand got tired.

It just took a little bit more twist to get back, and it didn't overshoot once I got it going.

I just need to work at it more.

--TURNING TARGET--

Let's do that one again. I think I got tired on that one.

I need a calibrated R.P.M. -- a button I could click off R.P.M. I can almost move this throttle just the right amount without looking at anything, but that does throw you off when I start looking at the R.P.M.

That's a tough one. It seems like when you're on it's easy. When you get off it's hard to get back on quickly. I kind of like it. I give it a 3.

RUNS 2180-2181 Pilot 21, TGSSC, .48in-lb DB, 24in-lb/g, WLT, Fixed-Base

--LEVEL TARGET--

That one was too loose, not objectionable but it was...compared to the other one. I give this one a 3.

It's the oscillation, so I overshoot. When I put in the correction, I overshoot and it's hard to get it back -- not hard, I hate to say hard, none of this is hard.

--TURNING TARGET--

I'd give that one a 2. And this set is just the opposite of the last set. In the turn it's easier and the set that we did just before in the turn -- it was harder. It seemed like I gave the level one a 2 and then the turn a 3, and on this one I gave the level one a 3. I give this a 2.

This one, the turn was easier and it was more relaxing on the arm. I really like that one.

It handles the amount of authority and control is good.

RUNS 3001-3002 Pilot 21, TGSSC, .48in-lb DB, 36in-lb/g, WLT

--LEVEL TARGET--

That was pretty easy.

Let's give it a 3.

--TURNING TARGET--

If that one was the same then I guess there wasn't too much I didn't like. Maybe let's give it a little bit higher. The other one too. Give it a 2. Let's give the level target 2 too. If they were the same conditions. Because I couldn't tell the difference.

Well, let's give them both 2's. Because it was pretty easy in the turn. So it must have been very easy straight and level. It was. Why I was hesitating, I thought it was overshooting a little bit and twist on me. But it's not. It's just -- I think it was just I was working too hard on it. It's not that difficult. In fact it's pretty good.

RUNS 3003-3004 Pilot 21, TGSSC, .48in-lb DB, 12in-lb/g, WLT

--LEVEL TARGET--

That's why I hesitated on the other one. Because this one -- I got used to the other one and I liked it. But this one, I think, I like better. But when you go from the other one to this one, you've got to compensate for it. Like the first one, it felt like it took more twist or a little bit harder twist. This one is really loose. But I kind of like this one better. Let's try it in a turn and see how it does. For that one, I would give it a 2.

The trouble is it's hard for me not to compare them now because I like both of them and I can tell the differences in them. Either one of them is fine. But my own personal preference is the second one.

But see the first one, the reason I wanted to give it a 3, I didn't realize was it took a little bit more twist than I like. But it wasn't annoying and it didn't prevent me from doing what I wanted to do. Whereas this one is really easy and I like that better. But either one of them looked good. I think I'd almost give them both the same but I really liked the second one better. It's sloppier and it's -- I like it. With a twist motion. It seems to be easier if it's looser to hold it on the target.

--TURNING TARGET--

Let's give it a 3. The reason because it's easier. I like it better. I think I can do it better than the other one but I

can't hold it as steady. If you'd give me a little time to practice, I'd rather fly with it like this. But the reason I give it a 3 it's just a little bit too loose. It takes a little bit more effort to hold it steady. But that's the way I would like it. I would like it like that compared to the other one. Even though I give it a 3, because I'm wobbling around on it, with a little bit of practice I would like that feel better than the other one because it's less difficult for me to twist it. I just have to concentrate a little bit more and hold it steady. I know I can do that. I think that's one of the things I didn't like about the twist was the force that it took to twist versus the force we had in the pitch. One of the measures of how difficult it is as close as I keep my air speed. If it's not difficult I can hold it on and look around more.

RUNS 3005-3006 Pilot 21, TGSSC, .48in-lb DB, 24in-lb/g, WLT

--LEVEL TARGET--

Whatever that one was, that was the best of what was done. Whatever you did to it, I liked that good in that level turn. We started off too high. I would give that one between a 1 and a 2. Why don't we just go ahead and give that one a 1. Of what I've seen today, that one was the best.

I didn't have any trouble with the force or any of the harmony or anything like that.

And I don't know why, but that one felt the best.

--TURNING TARGET--

It felt good. In the turn it's a little bit more difficult and I was bobbing a little bit in pitch. But yaw was good. How do we differentiate? It was just as good as in the level turn.

I think on this one about the turn and level, I'd say go ahead and build one. Let's give it a 1 too. That's unheard of, right?

Can you show me something better now? I've run out of scale.

Was that gradient in between the first two?

It felt like the second one was loose or less gradient and the first one was a little bit more. The first one wasn't bad and the second one I really liked. But that last one, I think that's a good median.

RUNS 3007-3008 Pilot 21, TGSSC, 2.7in-lb DB, 24in-lb/g, WLT

--LEVEL TARGET--

That's funny. I'm even getting where I like the twist. I know I like the button best of all.

It feels like there's a change. It's not bad but it feels like it takes a little bit too much to get it going and then to stop it. I hate even grading these things anymore. Let's give it a 3.

--TURNING TARGET--

It feels like it takes a little bit too much once it gets off to get it back on. I don't get the response readily. I'd give it another 3. But again, it's not bad. I would buy one of these too.

RUNS 3009-3010 Pilot 21, TGSSC, 4.8in-lb DB, 24in-lb/g, WLT

--LEVEL TURN--

Let's give it a 2. It was easier to hold on a target.

--TURNING TARGET--

I don't know. The pitch bothered me that time a little bit. Let's give it a 3. I don't know why the pitch bothered me.

RUNS 3011-3012 Pilot 21, TGSSC, 7.5in-lb DB, 24in-lb/g, WLT

--LEVEL TARGET--

Let's give that one a 4. I couldn't keep it on. When I got off it just took too much to get it back.

It's a response problem. I have to increase the force in twist until I can get it to move. I think that's why then I just automatically go to bank. I go to the path of least resistance.

--TURNING TARGET--

Let's give that one a 4 too. It's easier in the turn but it's still difficult. I think it's because when I get off, I've got to give it too much twist to get it back on. You know, when all the modes are pretty good, it's really hard to use this scale; the Cooper-Harper scale.

RUNS 3013-3014 Pilot 21, TGSSC, 9.6in-lb DB, 24in-lb/g, WLT

--LEVEL TARGET--

I don't like this one.

It took too much to get it going and then when I got it going to get it back going the other way it would overshoot or when it overshot to get it going the other way it was too much force in the opposite direction. Why don't we give it a No. 5. That one was annoying.

--TURNING TARGET--

Let's give that one a 5 too. Wore my hand out. It was too hard. That really affects the pitch too. My simulator seems to be doing pretty good. It's not making any noises.

RUNS 3015-3016 Pilot 21, TGSSC, .48in-lb DB, 24in-lb/g, WLT

--LEVEL TARGET--

I liked that one. That one puts you to sleep. Let's give that a 2.

--TURNING TARGET--

That's good. I'd give it a 1 but let's just give it a 2.

I would take that one. If you were selling those, I'd buy one of those as it is.

I went from a 1 to a 2 because we don't want to make it too good. I got myself into a box when I went to a 1 before. You might show me something better.

I'm not going to see anything else?

Give it a 1.

RUNS 3017-3021 Pilot 23, TGSSC, .48in-lb DB, 36in-lb/g, WLT

--LEVEL TARGET--

Adequate pilot performance for that task. Tolerable pilot work-load. So I'd go on up to satisfactory without improvement. I'd say yes for this task. I'd call it good.

So I want to go with a 2 then.

Forces and everything seem all right.

--TURNING TARGET--

Let me try that one more time. I don't like the pitch response on this for some reason. Let's go ahead and try it again.

I don't know whether I'm--I don't know. I'd say jumping around on it is a minor but annoying deficiency, that I'd want improved but that's in the pitch as much as anything. It's not the twist or coupling into it I don't think. Give it a 2.

Well, I don't like the--it's just that I'm not used to this type of airplane. The pitch, to me, feels sensitive. So I'd say that's mild but annoying. I don't know. I think I'd want to do something about that. The twist portion of it though, I didn't overshoot that much twist-wise or back and forth. So I'd say that was good. Anyway, maybe I'll just get used to the pitch.

<u>RUNS 3022-3024</u> Pilot 23, TGSSC, .48in-lb DB, 12in-lb/g, WLT

--LEVEL TARGET--

Here comes a big decision also. I was overcontrolling. I don't know if that implies a control response or not.

I was definitely tending to overcontrol. It's interesting now that I think about it. What is controllable?

Am I in danger of losing the airplane?

No. I'd say no to the next one I think.

Although I could have stayed close I guess. Pilot workload was tolerable. I'd go through that and say yes. Tolerable workload but I'd say it definitely warrants improvement and very objectionable. 6.

--TURNING TARGET--

Afraid to use it or something. I don't know. I'd like to try that one again. I just still really tend to overshoot with this thing.

I still tend to really overshoot with this. That's enough. For the level target the wings level I said was in the very objectionable but tolerable.

I put this in the same category. If I were using that constantly I'd be in a constant PIO with thin thing. 180° out of phase with it or something. Cooper-Harper 6.

I guess maybe I'm just getting used to the pitch. I don't know.

<u>RUNS 3025-3026</u> Pilot 23, TGSSC, .48in-lb DB, 24in-lb/g, WLT

--LEVEL TARGET--

I think I'd go up to the top with that. I don't know. I like it. I'd say excellent.

So that's a 1.

--TURNING TARGET--

I have a slight tendency to overshoot back and forth and sidewise that time. Was I holding a bunch of twist? I know I wasn't always matching his bank angle.

I liked that. I may have been screwing up using it. I still think there's a tendency with all of these things, like I told you before, to put something in and then not take it back out. At least I have that problem. But I'd say it's satisfactory on up to there and -- I don't know. I'd call it good I guess. 2.

RUNS 3027-3028 Pilot 23, TGSSC, 2.7in-lb DB, 24in-lb/g, WLT

--LEVEL TARGET--

I had a little more tendency to overshoot with this deadband than I did the last one. I don't know. But for some reason I guess I had a little more tendency to overshoot it. I don't know why. I'd say it's satisfactory, if the decision is would I use it like it is. I'd say mildly unpleasant. Give it a 3.

--TURNING TARGET--

There was some slight tendency to overshoot back and forth on this. I guess I'd give this the same thing; mildly unpleasant. Still a tendency to overshoot back and forth. I'm not sure what all that does. If I have a tendency to overshoot I would think I have a tendency to hold it where I've got it. Wherever that is.

But then I just hold what I have and then that causes other problems too. Still a 3.

RUNS 3029-3030 Pilot 23, TGSSC, 4.8in-lb DB, 24in-lb/g, WLT

--LEVEL TARGET--

That was a much, much more forceful motion that time. I think I might put this one -- I don't know. I'd say again minimal, mildly unpleasant deficiency and that it -- I don't know. I'd twist and not get anything and then when it finally broke out or whatever I'd get too much. Cooper-Harper 3.

--TURNING TARGET--

I have a tendency to jump around on it.

I'd give it probably the same thing. I still have a tendency when I was using it to jump past where I really wanted to be and concentrate it. I'd give it a 3 also.

RUNS 3031-3032 Pilot 23, TGSSC, 7.5in-lb DB, 24in-lb/g, WLT

--LEVEL TARGET--

That's where I lose him when I have to reverse with that much of a deadband.

For the same reason, I don't -- let's see. I'd go up to -- I don't know. I's say it's satisfactory without improvement but I'd say it's mildly unpleasant deficiencies. The deadband, I guess. I give it a 3.

--TURNING TARGET--

I'm twisting and getting nothing.

I'm not sure if I -- I don't know. This is far enough. Don't ask me why but I don't feel like I can give it as good as the one before. You're supposed to rate each one individually, though.

I'd say these do warrant improvement. 4.

RUN 3033 Pilot 23, TGSSC, .48in-lb DB, 24in-lb/g, WLT

--LEVEL TARGET--

Probably had a slight tendency to overshoot but that still felt good. So I'd go up to neglible deficiencies. I suppose I'd give that a 2.

RUNS 3034-3035 Pilot 21, TBC, .05lb DB, 5lb/g, WLT, Turbulence

--LEVEL TARGET--

It's going to be tough. That was a good one. I don't have many bad comments about that one. The only thing I could notice, using the button and keeping the lateral wasn't very hard. Let's give that a 2. The turbulence made the pitch a little bit hard but not that bad. It wasn't bad. Let's give it all a 2.

The turbulence made it more difficult in pitch than it did in directional control.

--TURNING TARGET--

That's kind of fun.

That one wasn't objectionable either. Let's give it a 2. The only thing I can tell with all the bouncing around is the response I get out of that little button and it's what I wanted. It's good. It's harder to -- I can't remember what I did with

the button before. It's harder to let off the trigger and then get back on the trigger. That kind of disrupts things. I'm pushing on that button pretty hard. I'm not used to it probably the button and the trigger.

RUNS 3036-3038 Pilot 21, TBC, .05lb DB, 1.25lb/g, WLT, Turbulence

--LEVEL TARGET--

I don't think this is going to work it. That one was squirrelly because it just went by. Let's give that one a 4.

It was difficult to keep it on the target because it would overshoot and then I couldn't get it back. Between the turbulence and the overshooting, it kind of added.

What I'm looking for is to easily keep it on the target when I move this little button. Right? And the problem with that one. . .

Let's do that one again.

Let's still call it a 4.

It overshoots too much.

--TURNING TARGET--

Let's give that one a 4 too.

Same type of problems.

But I got used to it a little bit more. It was a little bit better than the level one. I'm on the target longer than I would expect to be with all the commotion in here.

RUNS 3039-3040 Pilot 21, TBC, .05lb DB, 2.5lb/g, WLT, Turbulence

--LEVEL TARGET--

Not bad. Let's give that one a 2.

--TURNING TARGET--

I'd give that one a 2 also.

That one's getting easy there. If I would have concentrated or paid a little more attention I think I'd do a lot better. It wasn't too bad.

RUNS 3041-3042 Pilot 21, TBC, .05lb DB, 3.33lb/g, WLT, Turbulence

--LEVEL TARGET--

Let's give it a 3. It wasn't real great but it wasn't real bad. For some reason, I fell asleep in the middle of that one. I don't know why.

I just lost my concentration. It had nothing to do with the machine here. I think maybe what happened, it got so easy there for a minute I just let it go and let it get away from me.

--TURNING TARGET--

I found myself trying to twist the grip. Let's give that a 2. It's kind of nice.

It rates up there with the best of them.

It sort of felt like real turbulence because you know you can't get where you can just ignore it and the controls should do what you want. That's sort of what it did.

That's like flying in real turbulence. You don't want to fight it. Just let go of the airplane and then if you're trying to point it, go ahead and point it. You've got to ignore all of that bouncing around and whatever you've got to control the airplane do that.

You don't want to fight it. If the airplane comes up you don't automatically push down. Just hold what you have. That one felt like the best mode to do that.

RUNS 3043-3044 Pilot 21, TBC, .5lb DB, 3.33lb/g, WLT, Turbulence

Sometimes I might be shooting, sometimes I might not shoot and I should be shooting.

Directionally that thing was good. In pitch I bobbled a lot.

Okay, let's give it a 2. The only problem I think I had on that one was the pitch and there's nothing wrong with the pitch.

--TURNING TARGET--

Directionally, I liked it.

Let's give it a 2 then.

RUNS 3045-3046 Pilot 21, TBC, 1.0lb DB, 3.33lb/g, WLT, Turbulence

--LEVEL TARGET--

Let's give that a 4. I don't like that.

Because it takes too much push to get it going.

I like it a little bit lighter.

I think the turbulence makes all these modes look better.

It makes them appear to look better because everything is moving and it's, with the turbulence it's more difficult to hold it precisely on the target so you know, they are all good for aiming and with the turbulence today I'm passing through the target more than holding on the target.

I'm trying, though. On the last one I didn't like that.

--TURNING TARGET--

Okay, that one was easier but let's give that one a 4 too. It just boils down to I don't like to push that hard on the thing.

RUNS 3047-3048 Pilot 21, TBC, 1.5lb DB, 3.33lb/g, WLT, Turbulence

Let's give it a 2.

No real problems.

--TURNING TARGET--

A 2.

That wasn't bad, I let the airspeed get off a little, I guess I got away from it a little bit.

RUNS 3049-3050 Pilot 21, TBC, .05lb DB, 3.33lb/g, WLT, Turbulence

--LEVEL TARGET--

Now it felt like there was more turbulence.

That one just felt bumpier, but directionally it was good. 2.

It's more difficult to differentiate today.

--TURNING TARGET--

The more I use the button the more I like it.

Let's give it a 2.

That button, that little button there, it seems, it just feels natural moving that thing.

I just wanted to see how hard it was to get off it and come right back again.

Pushing on that button is like I've got my thumb on the reticle up there and I'm just moving that around.

RUNS 3051-3053 Pilot 21, TBC, 1.51b DB, 3.331b/g, WLT, Turbulence

--LEVEL TARGET--

Okay, I'm just going to do a little roll and get back on it.

I can't tell if he tripped me up, when I did the roll to get back on it was real nice but then it felt like too much force on the thumb to stay on it. It might have been my imagination cause of all the gyrations.

It felt like I was pushing a little bit harder than I wanted to on the thumb.

Okay, let's give that one a gee, I hate to even rate it, let's say a 3, I know it isn't a 2 and it may be a 4. Only thing I can tell is it took more force, I could keep it on pretty good but it took a little more thumb than I wanted.

--TURNING TARGET--

I think it might be a 4.

The push on the button, I don't get the response that I like as fast as I like it.

I'm not really confident about that rating, there is just something about that one.

Maybe I'm getting tired but I give it a 4 because I can't push it, it doesn't respond as quickly as I'd like it to.

RUNS 3054-3056 Pilot 23, TBC, .051b DB, 51b/g, WLT

--LEVEL TARGET--

Let's see here, I'll go on up past satisfactory and say it's good I guess. Cooper-Harper 2.

At times during that run, just a couple of times, I kind of wished I was getting more for what I was putting in but I'm afraid if I was in fact getting more I'd probably be in a giant PIO.

--TURNING TARGET--

Well I'd say that is satisfactory and hang close to him, I guess, I don't know.

I'd say fair and give it a 3, mildly unpleasant.

I don't know, I couldn't get it on him and, well, I don't know, I was tending to overshoot and then, I don't know, I'd leave the thing on.

RUNS 3057-3058 Pilot 23, TBC, .05lb DB, 1.25lb/g, WLT

--LEVEL TARGET--

Well, I can't even get it on him, god, I give up. It's a giant PIO.

I think I'd have to put that down into the, I don't know, I'd say it's not satisfactory.

Controllable? I could have always taken my hands off of it. Golly gee, I wouldn't say that was adequate performance. I'd go into major deficiencies, considerable pilot compensation required 8.

--TURNING TARGET--

I guess I'd go up the same way as the wings level it requires major, I don't know, considerable as opposed to intense I suppose. Anyway, I'll just say considerable. 8.

RUNS 3059-3061 Pilot 23, TBC, .05lb DB, 2.50lb/g, WLT

--LEVEL TARGET--

Well, I was down to only about two overshoots for everything I did with the turn. That might put me up to the warrants improvement category.

I think it's just too sensitive. I think it should be warrants improvement, moderately objectionable. 5.

--TURNING TARGET--

I'm aware of when I get all crossed up, it just seems easier to stay that way than it does to, you know when I rollout, match his bank then he's no longer in the pipper anymore.

Match him, bring him down, seems like I lose him forever. Well...

That's what I hate about this...oh, well.

To match his bank you know, when you've got, well, first of all, it starts at the very beginning when he starts rolling whichever way it breaks the tendency is to go after him with a thumb button initially and then just hold that as I roll and it just screws you up for the entire run.

Anyway, getting back on, this thing overshoots, I don't know, I still think it was too much tendency to overshoot so I'd say it's, yeah, it does warrant improvement and I'd say that is moderately objectionable.

I'll say a 5.

Another thing is, it's the same in each direction, right, the gradient, left or right?

I just had to think about that for a minute. I guess it should be.

<u>RUNS 3062-3063</u> Pilot 23, TBC, .05lb DB, 3.33lb/g, WLT

--LEVEL TARGET--

Still a tendency to overshoot. I'd say it warrants improvement and I'd call it minor but annoying, I guess, that amount of overshoot, so I might go with a 4 on this one.

It's still basically a sensitivity problem.

Except for the fact that I wish I were using my feet.

--TURNING TARGET--

Just kind of settle along that one. See I get out of the match when I do that. I just go all over the sky. I give up.

It's still hard for me to believe that this thing does not couple into about 6 other motions but anyway, especially on those wing level turns. I don't know, I'd say it's moderately objectionable, warrants improvement, I'd call that moderately 5.

Making it worse than it was but ...

<u>RUNS 3064-3065</u> Pilot 23, TBC, .5lb DB, 3.33lb/g, WLT

--LEVEL TARGET--

Still a tendency to overshoot there, I don't know, It's not that bad, so I'd say, well, it shouldn't overshoot so I'd say it warrants improvement, minor but annoying 4.

--TURNING TARGET--

Works out okay. I'd say it still has a tendency to bobble around that much, I didn't get -- well, maybe if I'd have gotten farther off of him, then I really seem to overshoot. I don't know. I'd say that warrants improvement and I'd say call that minor, probably very minor. I'd call it a 4.

RUNS 3066-3068 Pilot 23, TBC, 1.01b DB, 3.331b/g, WLT

--LEVEL TARGET--

I don't know, still had a slight tendency to overshoot, less though. I don't know. Is it satisfactory without improvement? Yeah I guess so. Then I'd say it's fair, some mildly unpleasant deficiencies. 3.

--TURNING TARGET--

I'm getting into this mismatch stuff again. Oops. It's easier to just put it on him than do this.

I don't know. If you only have to make small corrections with this thing, I'd say it's -- I'd almost call it good. But, boy making any kinds of larger corrections with it, I think it's still too sensitive. It's like dog crap. I don't know I'd still say it warrants improvement, minor, but annoying deficiencies I guess. 4.

There's just too much of a tendency there to PIO. The corrections get big, it's just.

RUNS 3069-3070 Pilot 23, TBC, .051b DB, 51b/g, WLT

--LEVEL TARGET--

I think there's still -- I still have a tendency to overshoot there, but I'd say that's okay without improvement. I'd still say it's mildly unpleasant I guess. I still have a tendency to overshoot, so I'd probably put it up into 3 I guess.

--TURNING TARGET--

Holding a sustained thing here for something. Well.

I don't know what happened there in the middle part of the run. I felt like I was holding sustained input in the thing.

Maybe I was pushing forward on the thing, I don't know. Sometimes hard to tell when I'm pushing forward or sideways I start gripping the thing. That was not a good run, but I'd put it I think in the same ballpark, I'd say it's satisfactory but there's still a tendency to overshoot, so mildly unpleasant. I'd give it a 3.

RUNS 3071-3072 Pilot 23, TBC, .51b DB, 51b/g, WLT

--LEVEL TARGET--

I don't know, based on that I'd put it up satisfactory and I don't know. Mildly unpleasant I guess.

Maybe I just find this thumb button mildly unpleasant, I don't know.

I guess maybe for no good reason, I don't know. Well, run that again. Maybe I didn't -- I don't know it just didn't feel comfortable I don't know what I did wrong.

Let me run that one again.

Maybe it was because my helmet is beginning to fit like a vice grip. That's okay.

Well, I guess this is not so bad after all. There's still a tendency to overshoot there. Well, wandering.

I don't know, I have a tendency to overshoot and wander and...I could hold it on there fairly well, but I'd call it mildly unpleasant I guess. 3.

RUN 3073 Pilot 23, TBC, 1.0lb DB, 5lb/g, WLT

--LEVEL TARGET--

I don't know, I'd put that as good I think. It's a toss-up. Occasionally during that I felt like I was ever so slightly overcontrolling and a couple of times I'd get behind and it feels like I needed more authority to get to it, so I don't know. Rate it a 2.

RUNS 3074-3075 Pilot 23, TBC, 1.5lb DB, 5lb/g, WLT

Well, now I'm really getting messed up. Let me start this one over. It was like a couple of times again there I found myself pushing on it, not getting what I wanted so I like stand my thumb to the side of it or whatever, push harder. Will you look and see if I ever -- do I get up against the limits of the, I probably wasn't, but it felt like I was.

Right in there I felt like I needed more.

Yeah, I'd say satisfactory. I think you can call that a good, although I don't know, sometimes like I said, sometimes I wish I were getting more movement out of it, but the overshoot problem which I absolutely hate was not there with that one. I didn't feel like I was in a constant PIO. I like that, I just -- you know there was like about three times through the run it felt like Oh, I need more here.

It might just be perceived, too, you find yourself pushing what you think....

I'd give it a 2, I think.

RUNS 3076-3077 Pilot 21, TGSSC, .48in-lb DB, 36in-lb/g, WLT, Turbulence

--LEVEL TARGET--

Good. Directionally, let's give it a 2, it was easy. The only things that made me get off was the turbulence in pitch, I couldn't hold it as steady as I could in azimuth.

--TURNING TARGET--

Good, the only problem I had was, and I don't call it too big a problem, was in pitch. I kept the trigger down because the pitch was getting off but I could get it back quickly, I thought. I'd give that one a 2, too. I thought it was a good one.

The turbulence caused me to bob in pitch.

RUNS 3078-3080 Pilot 21, TGSSC, .48in-lb DB, 12in-lb/g, WLT, Turbulence

--LEVEL TARGET--

That's funny, let's call that a 3. I really liked it but it surprised me, I didn't realize what you had done and I, starting out, I was really holding close to it I thought and then when it moved off, I overshot real bad. But I like it like that but it was more difficult for me for this run so let's give it a 3.

I liked the feel better but it surprised me, it was easy, I was holding it so easy to start with and then it moved off and I didn't realize the forces what they were and I overshot.

--TURNING TARGET--

I liked the feel of it better, but it was harder for me to do today and I don't know why.

I say, I liked the way it felt, I liked the feel better, but it was harder for me to hold it on the target today. I don't know why. Let's give it, and right away I started out bad, I hate to do this but let's say 4.

Let's leave it at that. It's just a little bit too loose.

RUNS 3081-3082 Pilot 21, TGSSC, .48in-lb DB, 24in-lb/g, WLT, Turbulence

--LEVEL TARGET--

Boy, it's funny in here. This thing is bouncing around.

It's not like you are riding in a airplane, it's more like a train or something slow.

It just kind of jiggles you along. Okay, that one I kind of liked, let's give it a 2.

No problems directionally.

--TURNING TARGET--

That one I liked, I'd give it a 2 and I counted over twenty seconds where I thought I was within 5 mils.

It almost gives, I can't tell the difference, between that one and the other one I gave a two but I think if we wanted to go higher I could give that one a higher one. Let's call it a 2. It was better than the other 2 that we gave but I don't know how much better.

Hey, I got a blister, yeah, remember when I first started using twist I complained it hurt, that I was going to wear gloves. Well, this week when I used the twist it didn't bother me at all and yesterday using the button I wore a little blister on my hand, that's funny isn't it.

I can feel it today but it's not bothering me. But the twist motion didn't do it, it was the button motion that did it. Well, I can feel it.

I don't know why that button, I don't know what I was rubbing my finger on.

The turbulence I think, it's not hokey but it's probably what makes it seem I chuckle at it, because you can hear things, you know, like blub, blub, blub, like you are bouncing along, or bobbing along. Whereas in an airplane it would just, there would be different sounds. It sounds like the whole machine is vibrating.

RUNS 3083-3085 Pilot 21, TGSSC, 2.7in-lb DB, 24in-lb/g, WLT, Turbulence

--LEVEL TARGET--

I believe I'd give that one a 3, I'm not sure.

Okay, let's give it a three.

It seemed like it just took a second or two to respond more than I liked. You know, a little bit longer when I twisted before it responded.

--TURNING TARGET--

Okay, that one I think I'd give a 2. Better in turn.

Not as much laggy response as I saw before.

RUNS 3086-3087 Pilot 21, TGSSC, 9.6in-lb DB, 24in-lb/g, WLT, Turbulence

--LEVEL TARGET--

5.

It's too much of a delay or whatever. Yeah, I don't get the response in time and it's too heavy. I don't like it.

--TURNING TARGET--

I give it a 5. It's better in the turn than it is straight and level. Once you get on, it's good; but once you get off, it takes too long to get it back on.

I felt I was making a lot of control inputs. Not when it's in a different configuration I wouldn't. Maybe a lot in one direction.

You know, when it gets off it takes more to get it back on--I don't overshoot.

I would guess that I'm using less inputs to the controller than in the other condition.

RUNS 3088-3089 Pilot 21, TGSSC, .48in-lb DB, 24in-lb/g, WLT, Turbulence

--LEVEL TARGET--

3.

It was pretty good.

--TURNING TARGET--

2 1/2. 2.

No real problems in fact, on that one, I started paying attention more to the airspeed and I wasn't too much at the target but I got the airspeed off.

RUNS 3090-3092 Pilot 21, TGSSC, 4.8in-lb DB, 24in-lb/g, WLT, Turbulence

--LEVEL TARGET--

4.

Didn't respond as quickly as I would like it. I don't know if I'm imagining it or not but it didn't seem like it did.

--TURNING TARGET--

I almost gave that a 3.

I kind of like the turn.

I'd say 3, going toward a 2. You know, maybe the blister on my finger is starting to effect me. I'm not sure.

RUNS 3093-3096 Pilot 23, 2"RP, 7lb BO, 20lb/g, WLT

--LEVEL TARGET--

Feels a little sloppy.

Felt a little sloppy but I'll go ahead.

I don't know. I'd say it's satisfactory without improvement, mildly unpleasant deficiencies. It just felt a little sloppier than I'd like. 3.

--TURNING TARGET--

It's just a combination of I don't know. Never mind. I thought I liked the foot pedals better but it just gets...well, never mind. I feel like I should be patting my head and rubbing my stomach at the same time when I'm trying to do this or something like that I don't know. It's frustrating.

If I get that input in there and then try to fly the airplane with some of what I would think would be a normal control input and then the airplane doesn't do what you think it's going to do. I just keep getting worse and worse off, and I keep overshooting when I just try to use it like that. Oh well. It's that thing of once you get close to a solution whether you've got the bank angle matched or not. I tend to just want to leave it there.

I don't know. I couldn't hold this in. I don't know what the problem is; whether it's well, I think it's satisfactory. I think it's just me that's screwed up today. I don't know, mildly unpleasant deficiency. 3. I couldn't hold it on there. I don't know what the problem is. Don't have a clue.

RUNS 3097-3099 Pilot 23, 2"RP, 7lb BO, 60lb/g, WLT

Oh, I don't know. I didn't mind that. I'd put that up good, negligible deficiencies. 2.

--TURNING TARGET--

I don't know. I'd give that a 3--something like that.

I just couldn't stabilize on it. I don't know if it's the fact that I had a frustrating morning, no lunch, a million things to do and I don't know or whether it's honestly, I don't know. I couldn't stabilize on it whether it was me or overcontrolling or whatever, I don't know.

RUNS 3100-3101 Pilot 23, 2"RP, 7lb BO, 40lb/g, WLT

--LEVEL TARGET--

Oh, I don't know. I'd say negligible I think for that. 2.

These rudder pedals run the scale a little bit quicker I think.

--TURNING TARGET--

Okay. I didn't mind that. I'd give that a 2 I think.

RUNS 3102-3103 Pilot 23, 2"RP, 15lb BO, 40lb/g, WLT

--LEVEL TARGET--

I could try that again but I don't know. When reversing is...I'd call that a mildly unpleasant deficiency I guess, something like that; like maybe a 3.

Once or twice I found myself giving it too much to get it to start and then going past it.

--TURNING TARGET--

Well pitch is what's giving me as much problem as any here. I don't know.

I'd still put that at about a 3. I don't know.

Like I said during the run, pitch was as much of a problem as anything so forget about that but I don't know I just couldn't settle sideways on it like I would have liked to either.

RUNS 3104-3106 Pilot 23, 2"RP, 25lb BO, 40lb/g, WLT

--LEVEL TARGET--

I don't know...something felt uncomfortable about it, I don't know. Maybe I should try it again.

I don't know whether it's a ... 2.

--TURNING TARGET--

I don't know. I'd give that a 2 also, I think. For general purposes, I don't think it's a 1 but I couldn't find anything wrong with it really.

I don't know. Either one, this one or this configuration, I could be talked into saying a 1 on either one of these. That's probably as good as I can do today.

RUNS 3107-3109 Pilot 23, 2"RP, 4lb BO, 40lb/g, WLT

--LEVEL TARGET--

I liked that I guess. I don't know what highly desirable is, but both the comments on the right are the same, aren't they--pilot compensation not a factor for desirable performance.

I don't know. I could go either way I guess.

I might give it a 1 I guess.

--TURNING TARGET--

I'll tell you what. The side to side control, although I was blowing everything else, the side to side control was about as good as I'd seen. I'd give that probably a 2.

RUNS 3110-3111 Pilot 23, 2"RP, 15lb BO, 20lb/g, WLT

--LEVEL TARGET--

Tends to overshoot--like there.

Well anyway, I don't know, I'd call it mildly unpleasant.

I'd say satisfactory configuration and I'd call it mildly unpleasant. 3. You know it was just a slight tendency to overshoot with the thing. You know, like it wouldn't be moving as much as I wanted to and then give it a little and that was too much.

Not just when it reversed. That's what I was just thinking--not just around whenever your deadband or your breakout area is. So I had a little tendency to overshoot in some of the other areas too but that would be just the gradient and I didn't think the gradient was all that bad anyway.

--TURNING TARGET--

But the other part the lateral control was still a little of the same tendency. I was going to say once you get on aim it's not that difficult to stay on aim but you get a little bit off then there's a tendency to overshoot. I'm trying to think how that would be a function of the breakout.

Well anyway, so I'd call that a 3 also.

RUNS 3112-3115 Pilot 23, 2"RP, 25lb BO, 20lb/g, WLT

--LEVEL TARGET--

I was having a tendency to overshoot there. I think I'd say the same thing about this as I did the last one. Up and say it's Okay--it was mildly unpleasant. 3.

You know it's primarily on reversing. I was trying to think about what was going on there when I was doing that run. I was trying to command a rate when you're on it as opposed to displacement when you're not.

--TURNING TARGET--

My legs are getting tired on this one. Darn.

My legs were actually getting tired on that, I don't know.

Those were the same forces I had in the level target?

Oh, my God. Oh, well. Gee, I'd say that warrants improvement. It's minor but annoying, but I don't know. Let me try the turning one more time. I think I was holding too much of the sustained input which...Let me try it and I'll try to keep it out this time.

I thought you were giving me a whole different configuration than before.

They feel okay now. I don't know. Maybe my leg got weak or something.

They still seem stiff. Oh, well.

Boy, I don't know. This is weird.

I'd put that in the same category as the level turning one with this configuration then. What did I say -- that was mildly unpleasant? 3.

I'd put it the same way. I don't know. During that run it seemed like the rudder pedal forces were higher than they were before but I guess not. They seem okay now.

Yeah. I'm just saying that for some reason during the run they seemed really high and now they don't seem much at all. I don't know. They just seem a little stiff.

RUNS 3116-3117 Pilot 23, 2"RP, 4lb BO, 20lb/g, WLT

--LEVEL TARGET--

I don't know. That seemed too sloppy on the pedals there. The first half of the run, or whatever, I was overshooting all the

time. Once you're stable on him it's okay, but getting to him is a problem. I don't know. I'd say it's too loose, warrants improvement, minor annoying, 4 or something.

--TURNING TARGET--

I don't know. I still think it felt a little sloppy. Somewhere between there and the one that felt like it was killing my leg trying to keep at him. I think I'd put that as a 4, although it's really difficult to get on the target. I didn't like it for that but actually, once you get on the target, it's not that difficult to stay on the target.

<u>RUNS 3118-3119</u> Pilot 23, 2"RP, 10lb BO, 20lb/g, WLT

--LEVEL TARGET--

I was trying to get out of the deadband there or the breakout. I just couldn't. I was hesitant to really stomp it. Anyway, I'll try a turning target but I'd say this is minor but annoying and maybe even a little more than that. Too much of a whatever ... breakout. So I just say no, deficiencies do warrant improvement and I don't know. I'd say it's minor but annoying, I guess. It's just that I couldn't settle on him. A little bit was not enough but then you'd come out of it and it would take you past him. 4.

--TURNING TARGET--

Probably wasn't worth a darn for getting on him. I don't know. I'm so confused. Actually, the lateral control or you know, the directional control left, right in the turn didn't seem as bad as it did wings level but then that might have been because I might have been holding sustained input again so.....

Actually, that one I'd say that that's a 3. I don't know. I just call that mildly unpleasant. I would say for tracking. When I got off of it in the roll in why it wasn't worth a darn for getting on him...but the whole thing?

Well, during the roll-in, the pipper came off of him and I don't know, it just didn't seem like it was ever going to get back on him.

Yeah, in terms of the ability to get it over to him. Once I got it over to him it was not that difficult.

<u>RUNS 3120-3121</u> Pilot 23, 2"RP, 7lb BO, 20lb/g, WLT

--LEVEL TARGET--

I give that a 4. I don't think I ever really stabilized on it through the whole run. I think I was in quite a few PIO's on the thing.

Quite a few overshoots.

I was going to say .. I might have been keeping close that time but I was trying to line the thing on him and I don't think I ever had it on him. I don't know.

--TURNING TARGET--

I'd give it the same thing. I think there is still a tendency to overshoot on it.

4 again on that for the same reason.

RUNS 3122-3123 Pilot 23, 2"RP, 7lb BO, 40lb/g, WLT

--LEVEL TARGET--

Let's say I'm not supposed to compare but I liked that better. I'd still say there's a slight tendency to, I don't know, still a slight tendency to overshoot when coming in and out of neutral or whatever but...

And I like that better. I forget what the last one was but anyway, I liked this gradient. I might even give it a 2. I don't know. I give it a 2.

Maybe I'd give it a 3, because I'm not sure if I like the breakout. I give it a 3.

--TURNING TARGET--

This makes it a little more difficult getting on. Come on.

I don't know. I suppose I give this a 3 also. I had trouble, I don't know if it's because of the increased force, that was one that seemed slow getting on him or seemed like it was never going to get on but once I got on him, it was easy to stay fairly close to him. Just kind of oscillating back and forth.

RUNS 3124-3125 Pilot 23, 2"RP, 7lb BO, 60lb/g, WLT

Boy, something else. Come on. Lagging behind him there.

That's too sluggish. I'd put that down into the 4, I think.

Where it does need improvement.

Well, give the rating forces I've talked about is a little too sluggish, displacement changed. What is this, 2 inches I'm doing now.

Yeah. That's reasonable. I kind of like that. Harmony, I don't know. I'm not sure if that's applicable since reasonable force,

it doesn't have anything really to do with the other control inputs. Control authority, I don't know. I'm not even sure if I was getting near full deflection but it just seemed sluggish and like I wasn't getting it as much as I wanted to.

--TURNING TARGET--

I need to give my arm a rest or something, I don't know.

It still seems like I'm putting in a step input and holding it.

Actually, there wasn't...I don't know. It wasn't bad. It still seemed a little sluggish. I put it in the 4 category. I don't know. It wasn't bad. I think I'd get tired of doing that for too long. A minute seems like a long time to be trying to kill somebody for a minute.

RUN 3126 Pilot 23, 2"RP, 10lb BO, 40lb/g, WLT

--LEVEL TARGET--

I couldn't get it on him. I don't know. Tends to constantly overshoot, especially on neutral or whatever when reversing. Let's see. It warrants improvement, I don't know. I'd put that in the 4 category I think.

RUN 3127 Pilot 23, 2"RP, 4lb BO, 40lb/g, WLT

--LEVEL TARGET--

Better. Still maybe a little trouble just when he gradually releases, trying to hold it right on him. I don't know. This one I don't know what the gradient is. I don't know. It seems a little...maybe not.

Now it feels stiff. It felt sloppy. I don't know. Not necessarily weak but just kind of sloppy. Anyway, whatever that means. I'd say it's got mildly unpleasant deficiencies. You know, it's okay. I guess I'll give it a 3.

RUN 3128 Pilot 23, 2"RP, 7lb BO, 40lb/g, WLT

--LEVEL TARGET--

I don't know. Still have a tendency to overshoot with that. I don't know.

I'd be convinced to call it anything. Mildly unpleasant, I guess. I give it a 3.

RUNS 3129-3130 Pilot 21, 2"RP, 7lb BO, 20lb/g, WLT, Turbulence

--LEVEL TARGET--

Well, let's give that one a 3.

It wasn't too bad. It's just getting used to the pedals again and I liked the feel on that one.

I probably could give it a 2 but I want to save a higher one. I want to see something better.

I did notice right off the bat that I can probably get more time, maybe less time of trigger pull but more time on the target. You know what I'm saying. I can let go of the trigger and hold the trigger down easier now.

--TURNING TARGET--

I would rate that one between 3 and 2. Let's give it a 2 just for kicks.

RUNS 3131-3132 Pilot 21, 2"RP, 7lb BO, 60lb/g, WLT, Turbulence

--LEVEL TARGET--

I'd give that one a 2.

It was just, with the feet it was easier, it didn't, it was just easier.

--TURNING TARGET--

I'd give that one a 2, too.

You know I gave the last one in a turn a 2, probably between the two this was the better.

RUNS 3133-3134 Pilot 21, 2"RP, 7lb BO, 40lb/g, WLT, Turbulence

--LEVEL TARGET--

I hate to go crazy but let's give that one a, drop down to a 5. The problem is it's too difficult to get back on the target, it's not bad once I'm on it but when I overshoot I can't stop it from overshooting, too loose.

It's not hard to get it on but once you are off it's hard to get back, or maybe that isn't the right word, I'm passing through the target more.

Maybe I should say it's not hard to get it on the target but it's hard to hold it there.

--TURNING TARGET--

Let's say a 4 on that one. Little bit easier than the turn.

I said a 4, maybe it is almost a 3, it wasn't too bad.

RUNS 3135-3136 Pilot 21, 2"RP, 7lb BO, 20lb/g, WLT, Turbulence

--LEVEL TARGET--

I'll say a 3 for that and too much pedal movement and not enough response up there on the screen.

--TURNING TARGET--

Okay, I'd say another 3 for that one. That one wasn't too bad, maybe I'm just getting a little bit used to it.

RUNS 3137-3138 Pilot 21, 2"RP, 7lb BO, 40lb/g, WLT, Turbulence

--LEVEL TARGET--

I'd give it a 3. It wasn't too bad but it wasn't great either. Let's give it a 3.

--TURNING TARGET--

Let's give that one a 3, too for lack of anything else. It wasn't too bad.

I got off in the beginning, I tried to, a little bit hard, or a little over-agressive on the rudder.

RUNS 3139-3140 Pilot 21, 2"RP, 7lb BO, 60lb/g, WLT, Turbulence

It's getting tough. I can't tell the differences anymore.

From this one and the other one I can't tell the difference. I would, just to keep a median there, I'd give this one a 3, too. It wasn't bad.

The last three sets of runs I really haven't been able to tell too much difference. I could feel, it seemed like I was using more pedal but the reactions up on the screen, I can't tell much difference.

--TURNING TARGET--

It might be my imagination but on this one it felt like it took more rudder pedal to get on the target and then I had to put in opposite rudder to stop it and I'd overshoot and that was a little bit annoying. But it wasn't that difficult, but you know to go from a 3 to a 4 maybe just because of that fact, but it seemed like I could keep it on the target pretty well.

Let's give it a 4 just because of the fact it felt like to me it took too much pedal to get there and then too much opposite pedal to stop it. So I'd say 4.

And I am using my toes.

And I am bracing the sides of my legs on the side of the cockpit here.

RUNS 3141-3142 Pilot 21, 2"RP, 15lb BO, 40lb/g, WLT, Turbulence

--LEVEL TARGET--

Not too bad, let's give that one a 3. The only comment I'd make is that my feet got tired on that one.

--TURNING TARGET--

A little bit easier in the turn, let's say 3, could be a 2 but let's say 3.

All these with the rudder today in those turns it's harder for me to get on to start with but once you do it's not too bad to stay on.

RUNS 3143-3144 Pilot 21, 2"RP, 25lb BO, 40lb/g, WLT, Turbulence

--LEVEL TARGET--

Okay, that one I know I don't like. I would go to 5 on that one. there is too much pedal and too much force to get it going and then stop it in the opposite direction.

--TURNING TARGET--

Okay, I'd give it the same thing, a 5 and the same comment, it's just too stiff.

And you know, the noise in here, it does make you forget the turbulence. All the clanging around in here. The engine noise, I think that's good.

You know how every now and then I would chuckle at the motions in here? Today I don't have that in a sense.

RUNS 3145-3146 Pilot 21, 2"RP, 4lb BO, 40lb/g, WLT, Turbulence

Okay, to go from 5, if maybe we saw this one before, I'd give it a 2 just because of the drastic difference. It's just easier, it just feels better. I don't know if I'm scoring it better but it feels better. It's easier to do.

Maybe that is too much but just from the last one to this one, it's a big difference. That would be the top and bottom of my scale probably.

That was a drastic change.

--TURNING TARGET--

Okay, same comments and that is the first one initially in the bank that I could stay with him. I'd give him a 2, too.

RUNS 3147-3148 Pilot 21, 2"RP, 10lb BO, 40lb/g, WLT, Turbulence

--LEVEL TARGET--

I'd say that one I didn't get the response that I wanted and the authority with the pedal. I'd give it a 3, on the way to a 4.

--TURNING TARGET--

Okay, a 3 or a 4 on that one, too. Too much delay, or too much pedal to get the response I want.

I'd say a 4.

RUNS 3149-3150 Pilot 21, 2"RP, 20lb BO, 40lb/g, WLT, Turbulence

--LEVEL TARGET--

3.

I'm getting confused in here now. I can't tell, I've done so many, I can't tell what I'm doing anymore.

And I say that because I didn't like that one at all but it wasn't too hard.

Seemed like there was less pedal movement but the same force so that's, didn't the one before I gave a 4?

Well, this one felt a little bit better, the only thing I seemed like I noticed was the amount of pedal travel versus the force, maybe I'm all screwed up, I don't know.

--TURNING TARGET--

Okay, for keeping it on the target probably a 3, for liking it a 4.

Let's say 3, I guess.

Let's go to a 4. Did I say 4 for the level too?

Let's say 4 for that too.

RUNS 3151-3152 Pilot 23, 3"RP, 7lb BO, 60lb/g, WLT

--LEVEL TARGET--

I like that for tracking. Again, with that I would start to lose him just as he reversed like I wasn't giving it enough to go get him and I had a lot of pedal available. I don't know. It was dumb. I just seemed to push in more...but for following him and the feel and everything else, I liked it. I would probably, I don't know, say a 3, I think.

I could almost be convinced to call it a 2, I suppose.

--TURNING TARGET--

I might put that in...it seemed slow getting on him. It required moderate pilot compensation.

I'd do 4, I think, for that.

In general, I don't think I...the 3 inch throw...maybe I've gotten used to the 2 inch. It seemed like too much. I'm not using it all either. I know I should be at times but...it seems uncomfortable using that much.

RUNS 3153-3154 Pilot 23, 3"RP, 15lb BO, 60lb/g, WLT

--LEVEL TARGET--

I'll call that a 4, I think. Minor but annoying. I think I reversed my rudder inputs or whatever about twice as many times as the target reversed its direction there. Requires moderate pilot compensation or whatever. I just ended about zero. You know, when he'd reverse direction, it was difficult to get back on him.

--TURNING TARGET--

Now right there like...I was pressing and not getting what I thought I was going to get.

I'd call that a 4 also. It just seemed difficult to settle it on him. There were times like I mentioned it was kind of frustrating. I was pushing and the nose was not moving.

RUNS 3155-3156 Pilot 23, 3"RP, 4lb BO, 60lb/g, WLT

--LEVEL TARGET--

I'd put that up in minimal pilot compensation--probably a 3. Actually, maybe better than that. There, I didn't have the same problems I've had like in and about zero reversing. The only

problem I had with this one was back to the old problem of I wasn't getting the range that I really wanted and for some reason I had more rudder pedal available...I should have been going in after it but it feels awkward sticking too much in.

--TURNING TARGET--

I'd give that about a 3 also. It was easy to hold the roll close to it or kind of. For making a big correction to him like after the roll off and if I don't end up lined up big corrections still, with this configuration seem difficult to make. But in and about zero I kind of like the way the thing feels. So I'd give it probably a 3.

<u>RUNS 3157-3158</u> Pilot 23, 3"RP, 10lb BO, 60lb/g, WLT

--LEVEL TARGET--

Pushing and pushing and it seems like just now that it starts to move and a little too much. I overshot a little that way.

I don't know. I kind of liked it except there was a tendency for him to get away from me when I first started then I'd just overshoot slightly. If I could keep moving with him, it was okay. I don't know. I think I'd call that a 3.

He'd start moving - I couldn't start with him and then I'd overshoot him slightly.

Like he'd start moving to the right, I'd lag behind and then overshoot a little too far to the right and I'd get on him.

--TURNING TARGET--

It takes a couple of overshoots to get on him...to stay on, I guess.

This is the same kind of thing. I think I'd give that a 3 also.

I think I'd call that a 3 for the same reasons. Slow and kind of sluggish getting over to him and then I'd overshoot.

<u>RUNS 3159-3160</u> Pilot 23, 3"RP, 20lb BO, 60lb/g, WLT

--LEVEL TARGET--

I didn't like that. It was doing a lot of ... it's just stomping ... I'd call that a 4.

-TURNING TARGET--

Difficult to stay on or about him. I'd give it a 4 for the same reason. You know the thing of stepping and not getting enough, stepping more and getting too much.

RUNS 3161-3163 Pilot 23, 1"RP, 7lb BO, 40lb/g, WLT

--LEVEL TARGET--

Initially, it tends to overcontrol. I don't know. My personal feeling...the 3 inches seemed like too much. The 1 inch seems like not enough--that's initially anyway. I mean not enough of a throw.

Too much of a tendency to overshoot. I don't know. I was giving it too much.

I guess it's hard for me to make...well, eighth inch corrections or whatever.

I was using mainly my feet, I think.

So what did I say about that? I don't know. I think I'd give it a 3.

--TURNING TARGET--

I kept tending to overshoot. I think I'd give that a 4. It's just really difficult to settle on him. I kept...I was off of him...I'd get it back on him and I'd always overshoot.

RUNS 3164-3165 Pilot 23, 1"RP, 7lb BO, 60lb/g, WLT

--LEVEL TARGET--

Still like trying to control the thing with step inputs it feels like.

Like I said...in and above zero especially or wherever I was ... Actually, not just that. Trying to match his rate it felt jerky on the controls. I don't know. I'd say fair, mildly unpleasant deficiencies, minimal pilot compensation. 3.

Instead of the feeling that like well, I was matching it smoothly pressing it in, it was kind of like I had to jerk it around a little, I don't know.

--TURNING TARGET--

I don't know...I'd almost give it a...it still felt a little jerky. You know the turning target...tendency to compensate just a little bit by using other than the foot pedals. It's easier to do that. Like roll out bank or roll in bank or something to help. So I guess I was applying minimal pilot compensation and mildly unpleasant deficiencies. I give it a 3, I think.

I guess it's not bad. I didn't really mind it. It's still a little squirrelly though, I don't know.

RUNS 3166-3167 Pilot 23, 1"RP, 15lb BO, 60lb/g, WLT

--LEVEL TARGET--

When I step on it and don't get what I want, I think there's a tendency to want to roll in after him then.

Some of the bank angle comes unconsciously from that. Once you get his rate matched, it's not hard.

I don't know. I might even give that a 2. That didn't feel too bad although it's still sluggish in and about zero. Maybe to be consistent, I should probably call that a 3.

Just because it was sluggish getting it to reverse in or around zero rudder pedal displacement.

Seriously, is there some way you could lock my bank angle and just make me do it with my feel. Some of these things might show up a lot better. Oh, well.

--TURNING TARGET--

I guess about the same as the level turn. Still felt a little sluggish around zero and I don't know. Actually, not bad though. I don't know. Actually, not bad though. I don't know - both of those I'd call it a 3, I think.

Mildly unpleasant, minimal compensation required.

RUNS 3168-3170 Pilot 23, 1"RP, 25lb BO, 60lb/g, WLT

--LEVEL TARGET--

I don't know. Maybe I'm gaming him more but I don't know, I might even give that a 2, for no reason, I don't know why. I'm getting screwed up or something. Maybe I was gaming him but I didn't have trouble in and around zero like I did.

--TURNING TARGET--

That was terrible. I don't know. Maybe my legs are getting tired from using this stiff rudder force or something. I don't know. I couldn't do anything with them so I don't know. I'd give it a 4. The one before this too. Let me run the level turn thing again.

I think I was guessing him, I don't know.

--LEVEL TARGET--

Messing up. Three overshoots so far. Just lagging behind him and overshooting.

I don't know. I suppose I'd put that in the 3's. I would say maybe 4. I don't know. The tendency is there to overshoot and I guess that's minor but an annoying deficiency. I might give it a 4. The first time I flew, I think I might have been gaming him or something, I don't know; or not trying or something.

4. It was really consistent on that.

RUNS 3171-3173 Pilot 23, 1"RP, 20lb BO, 60lb/g, WLT

--TURNING TARGET--

You know, the thing is, it takes so much force to get the thing moving, I'm not using them.

I don't think I used it more than one time during the run or something like two times.

It was like I was unconsciously pushing about what I thought would be right, and so I just bank or something, I don't know.

Well come on here. Back there, it just doesn't move when you want it to move. See that is just holding what I have now.

I don't know. I guess I didn't like that very well.

I'd probably give it a 4. I'm not sure.

At times it was like I would try it and not get anything and then again tend not to use it, I guess. I don't know.

--LEVEL TARGET--

See there. I was trying to roll in bank.

It just takes too much to get it going. I think I'd give it a 4 for that.

RUNS 3174-3175 Pilot 23, TGSSC, .48in-lb DB, 24-in-lb/g, WLT, Turbulence

--LEVEL TARGET--

I think I'd want to make the twist lighter.

I think I'd want less in twist. I may be kidding myself. (No rating given)

RUNS 3176-3177 Pilot 23, TGSSC, .48in-lb DB, 12-in-lb/g, WLT, Turbulence

--LEVEL TARGET--

I liked that better. The first one it bumped way off or end up off of him for whatever reason and I assume it is being bumped off. Seems like it took forever the frequency of it, getting

back on--just about the time you get back on you get bumped off again, this time I could get back on quicker than before. Like there is a mismatch of the frequency that I was being bounced around at and the frequency that I ended up using my controller at. I couldn't find anything--I'd probably give it a 2.

--TURNING TARGET--

I don't know if I'm doing that to it or not. I guess so.

A couple of times I felt myself overshooting like I knew it was my fault, but I still--I don't know what else you could do to it. Stick with the 2.

RUNS 3178-3179 Pilot 23, TGSSC, .48in-lb DB, 24-in-lb/g, WLT, Turbulence

--LEVEL TARGET--

I don't know. Really difficult to tell. I might call it a 3. I overshot a few times, but still it seemed like I had the ability to get it back there quickly which is good because you are not going to be able to stabilize on him for long.

--TURNING TARGET--

Still in the 2 or 3 range. Nothing wrong with it I don't think. It's hard to tell.

RUNS 3180-3181 Pilot 21, TBC, .05lb DB, 3.33lb/g, WLT, Turbulence

--LEVEL TARGET--

3. No real problems.

RUNS 3182-3183 Pilot 21, TBC, .05lb DB, 2.5lb/g, WLT, Turbulence

--LEVEL TARGET--

Let's give that one a 3 too.

Because it overshoots too far on me.

--TURNING TARGET--

It was easier in the turn, so let's say 2. Only because it was easier in the turn. I had this same feel, it kind of overshot but not, I don't know why it was easier.

The initial turn was easy to track it too.

RUNS 3184-3185 Pilot 21, TBC, .051b DB, 1.251b/g, WLT, Turbulence

--LEVEL TARGET--

Let's give that one a 5. It's just too loose, it was all over the place.

In the back of my mind I don't know if it is me or if it is the configuration. That one was really sloppy.

--TURNING TARGET--

Let's give that one a 5. It's just too loose.

Seemed like I liked it loose before but with the turbulence--between the turbulence and being loose, it's a constant correction. Not bad though.

RUNS 3186-3187 Pilot 21, TBC, .051b DB, 51b/g, WLT, Turbulence

--LEVEL TARGET--

A 2.

--TURNING TARGET--

2, 2, 2, 2.

My airspeed was close and I held it in the bank. It was pretty easy to do.

Call that a 2, but mark somewhere down a 1 by that configuration just for fun, in case we come back to it again.

It's not a 1, but of all that I've seen today, that would be the best one. I got a big jolt in here.

It just banged my head on--good thing I'm wearing a helmet. I haven't felt a jolt like that before here.

RUN 3188 Pilot 21, TBC, .051b DB, 3.331b/g, WLT, Turbulence

--LEVEL TARGET--

That one is a hard one. That is between a 3 and a 4. Let's say 3.

It felt like it was just a little bit looser than the one before. It would overshoot a little bit on me, not bad.

On the one we just did. To me that one is interesting, because I felt like I could score pretty good but there was just something about it that I didn't like that much.

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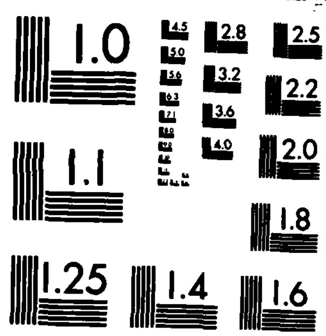


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

RUNS 3189-3191 Pilot 21, TBC, .5lb DB, 3.33lb/g, WLT, Turbulence

--LEVEL TARGET--

Feels like there is more turbulence in here this time.

That's not a bad one. Between a 3 and a 2. It seems like there is more turbulence. Let's give it a 3. It's between a 2 and a 3.

Can't put my finger on it. It's not a bad one. The increased turbulence which I guess there isn't any....

--TURNING TARGET--

3. It was just a little bit tough to move it back and forth.

It's almost a 2.

I think it could have been a little better if I could have caught him right away in the turn.

Basically the roll in and then I got off and couldn't catch up.

RUNS 3192-3193 Pilot 21, TBC, 1.5lb DB, 3.33lb/g, WLT, Turbulence

--LEVEL TARGET--

No doubt about that one. Let's give it a 5. It was bad. Just too much to get it going.

--TURNING TARGET--

I think I was using it a lot. Give it one better than I did level. It's better. 4.

RUNS 3194-3195 Pilot 21, TBC, 1.0lb DB, 3.33lb/g, WLT, Turbulence

--LEVEL TARGET--

3. It really felt good but it felt like I had to use a little bit too much force to get it going. It was a good one.

I almost would say a 2. Between a 2 and a 3.

--TURNING TARGET--

I really liked that one and I'd give it a 2, but I think I'll say a 3, because it felt like I had to work a little harder with my thumb.

It wasn't--let me read some of the words here. Let's say 3.

APPENDIX F
CONTROLLER USEFULNESS QUESTIONNAIRE

At the end of each series of runs involving a given controller and task a controller usefulness questionnaire was completed. The purpose of this form was to aid in accessing the appropriateness of the controller for a given mode/task combination.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 1 Date 3 Jan 1983

Controller and Task Two Inch Rudder Pedals, Wings Level Turn Mode, Air-to-Ground Weapon Delivery

1. Was the controller useful for accomplishing the flight task?

   Yes. I found it took minimum time to operate somewhat effectively. It was easier than the side stick to master.

2. Did it feel natural to use the controller for the mode being controlled?

   Yes. Generally, I use the rudders to make small heading changes anyway, i.e., ILS and GCA approaches.

3. Can you foresee any problems in using these controllers in an operational environment?

   Not for small heading changes. Very good for headings < 10°; OK for heading < 30°.

4. Any general comments about the controllers?

   The wings level turn using the rudders seems very effective for target acquisition. The overall harmony between ailerons and rudder is fair due to the sensitivity in the lateral axis.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 2 Date 3 Jan 1983

Controller and Task Two Inch Rudder Pedals, Wings Level Turn Mode, Air-to-Ground Weapon Delivery

1. Was the controller useful for accomplishing the flight task?

   Sure was - seems to be the most logical choice.

2. Did it feel natural to use the controller for the mode being controlled?

   Yes.

3. Can you foresee any problems in using these controllers in an operational environment?

   No - not at high speed during air-to-ground attack.

4. Any general comments about the controllers?

   With the "Low" #/G there seemed to be a tendency to overshoot laterally. With High #/G there seemed to be a lag -- probably the "Lag" in my applying sufficient force.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 1 Date 4 Jan 1983

Controller and Task Twist Grip Sidestick, Wings Level Turn Mode, Air-to-Ground Weapon Delivery

1. Was the controller useful for accomplishing the flight task?

   Yes, to a certain extent - it takes longer to get used to (than WLT on δ_{Ped})

2. Did it feel natural to use the controller for the mode being controlled?

   Not initially. It becomes natural but not as natural as rudders.

3. Can you foresee any problems in using these controllers in an operational environment?

   Some. Due to the natural movement of the hand, I feel pilots will induce cross-coupling in other than mission roles. Also the wrist gets very tired after just a half dozen passes, while in the other axes the hand does not tire.

4. Any general comments about the controllers?

   I feel with practice and the proper dead band, breakout, and "force" per g, this could be a useful controller.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 2 Date 4 Jan 1983

Controller and Task Twist Grip Sidestick, Wings Level Turn Mode, Air-to-Ground Weapon Delivery

1. Was the controller useful for accomplishing the flight task?

   Yes.

2. Did it feel natural to use the controller for the mode being controlled?

   Yes, but not as natural as the rudder pedals.

3. Can you foresee any problems in using these controllers in an operational environment?

   No.

4. Any general comments about the controllers?

   There seemed to be a slight tendency to couple roll with the twisting motion in several configurations.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 1 Date 5 Jan 1983

Controller and Task Twist Grip Sidestick, Wings Level Turn Mode, Air-to-Ground Weapon Delivery

1. Was the controller useful for accomplishing the flight task?

2. Did it feel natural to use the controller for the mode being controlled?

3. Can you foresee any problems in using these controllers in an operational environment?

4. Any general comments about the controllers?

Task was side stick deadband.

I think if more control was available in the side stick controller, even more could be gained in this exercise, i.e. vary the force with deadband. Presently the deadband to force is constant slope. If this slope could be changed or at least in the deadband more variables could be evaluated.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 1 Date 6 Jan 1983

Controller and Task Thumb Button on Sidestick, Wings Level Turn Mode, Air-to-Ground Weapon Delivery

1. Was the controller useful for accomplishing the flight task?

   Semi-useful. It took a lot of compensation to do the flight task. I had a cross coupling tendency with roll and trigger finger.

2. Did it feel natural to use the controller for the mode being controlled?

   Not really. I think the thumb has trouble: too many fine tasks while the hand is doing other tasks. Both are working rapidly in different directions.

3. Can you foresee any problems in using these controllers in an operational environment?

   Yes, although most fighters have an aileron trim switch, it is not often used. With this controller much movement is required for the thumb to the left and right.

4. Any general comments about the controllers?

   This is the most difficult controller seen so far. Probably due to the added function required by the thumb. The hand is already fairly busy as it is.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 2 Date 6 Jan 1983

Controller and Task Twist Grip Sidestick, Wings Level Turn Mode, Air-to-Ground Weapon Delivery

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes - but again not as natural as the rudders.

3. Can you foresee any problems in using these controllers in an operational environment?

   No

4. Any general comments about the controllers?

   I preferred having a slight deadband in the twist action - but was having some difficulty in pitch. Whether this was due to deadband or not - I don't know.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 3 Date 10 Jan 1983

Controller and Task Two Inch and Three Inch Rudder Pedals, Azimuth Pointing Mode, Air-to-Ground Weapon Delivery

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes definitely

3. Can you foresee any problems in using these controllers in an operational environment?

   No

4. Any general comments about the controllers?

   The use of the rudder pedal for aiming is a natural movement from conventional controls. The stafe maneuver on a conventional aircraft is very similar; however, the amount of side to side movement available is much greater in the simulator than with a fighter such as the F-4 and/or A-7.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 2 Date 11 Jan 1983

Controller and Task Thumb Button on Sidestick, Wings Level Turn Mode, Air-to-Ground Weapon Delivery

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   "Sort-Of" - It was my least favorite controller but a little practice, it did feel natural.

3. Can you foresee any problems in using these controllers in an operational environment?

   No

4. Any general comments about the controllers?

   As I said, it was my least favorite of the three. The five pound deflections did not feel "Natural" but minor inputs necessary to "walk" the cross across the target felt OK - there may be a very slight tendency to couple inputs with pitch and a real tendency to couple large inputs to roll - overall, it was OK though.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 4 Date 11 Jan 1983

Controller and Task Two Inch Rudder Pedals, Azimuth Pointing Mode, Air-to-Ground Weapon Delivery

1. Was the controller useful for accomplishing the flight task?

   Absolutely

2. Did it feel natural to use the controller for the mode being controlled?

   Yes

3. Can you foresee any problems in using these controllers in an operational environment?

   No

4. Any general comments about the controllers?

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 3 Date 14 Jan 1983

Controller and Task Twist Grip Sidestick, Azimuth Pointing Mode, Air-to-Ground Weapon Delivery

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

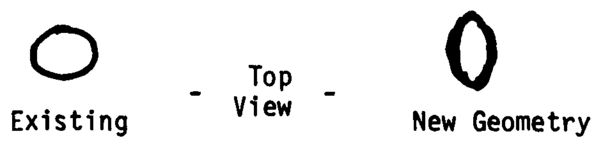
   Yes, better than I expected. Became better to me the more it was used.

3. Can you foresee any problems in using these controllers in an operational environment?

   No

4. Any general comments about the controllers?

   As was mentioned on the tape, my hand slipped when high torque forces were required; however, the slippage was not excessive. If possible, you might consider changing the stick geometry to provide more leverage for torque e.g.



   I was unaware of any torque input while rolling during the set up maneuver (was briefed post mission by the MSN controller but I had twisted while rolling). I observed no objectionable results caused by doing this in the simulator, but operationally it could be unacceptable.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 5 Date 17 Jan 1982

Controller and Task Two Inch Rudder Pedals, Azimuth Pointing Mode, Air-to-Ground Weapon Delivery

1. Was the controller useful for accomplishing the flight task?

   Yes, rudder control was extremely helpful in acquiring and maintaining targets.

2. Did it feel natural to use the controller for the mode being controlled?

   Very natural and with limited time on target using rudders seemed like it was easy to accurately point aircraft.

3. Can you foresee any problems in using these controllers in an operational environment?

   No

4. Any general comments about the controllers?

   Higher rudder forces were more acceptable to me. It was easier to acquire the target and less tendency to overshoot with higher forces.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 5 Date 20 Jan 1983

Controller and Task Twist Grip Sidestick, Azimuth Pointing Mode, Air-to-Ground Weapon Delivery

1. Was the controller useful for accomplishing the flight task?

   Yes, twist controller was very useful in acquiring and maintaining the target

2. Did it feel natural to use the controller for the mode being controlled?

   Twist controller felt natural for proper sense but the tight grip required was not natural. I had difficulty in using roll and twist or pitch and twist simultaneously. I had to first roll or pitch to acquire the target then use twist.

3. Can you foresee any problems in using these controllers in an operational environment?

   Twist controller requires too tight of a grip to accurately perform azimuth pointing.

4. Any general comments about the controllers?

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 6 Date 24 Jan 1983

Controller and Task Two Inch Rudder Pedals, Wings Level Turn Mode, Air-to-Ground Weapon Delivery

1. Was the controller useful for accomplishing the flight task?

   Yes, because it reduced the amount of aileron control necessary to turn the aircraft to almost zero.

2. Did it feel natural to use the controller for the mode being controlled?

   Yes, the feel of the rudder to control the turn felt natural. It was difficult to resist trying to turn the aircraft with bank, however.

3. Can you foresee any problems in using these controllers in an operational environment?

   No.

4. Any general comments about the controllers?

   The amount of rudder input required to start and stop the turn is of course critical in how quickly the targets can be acquired. The lighter breakout force induces over-controlling and overshoots, especially in attempting to transition to the second target. Since it is more difficult to precisely control the force and displacement generated by the legs than by the arms, it almost requires a constant speed turn, with the rudders supplying "on" and "off" commands to the turn commands. It will require a lot of practice to become adept at selecting the proper turn rate and lead points if the controller can command a variable rate of turn.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 7 Date 24 Jan 1983

Controller and Task Two Inch Rudder Pedals, Wings Level Turn Mode, Air-to-Ground Weapon Delivery

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Very natural

3. Can you foresee any problems in using these controllers in an operational environment?

   Not for task accomplished.

4. Any general comments about the controllers?

   Excellent for gross acquistion.
   Excellent for fine corrections.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 6 Date 25 Jan 1983

Controller and Task Twist Grip Sidestick, Wings Level Turn Mode, Air-to-Ground Weapon Delivery

1. Was the controller useful for accomplishing the flight task?
   Yes, it allowed the heading corrections to be made with less and much smaller control inputs

2. Did it feel natural to use the controller for the mode being controlled?
   No - the wing-level turn more closely resembles a yaw, which is more likely associated with the rudder pedals

3. Can you foresee any problems in using these controllers in an operational environment?
   Yes. The tendency for the pilot to "tighten up" on the stick grip will interfere with the small, precise inputs required to maintain the sight on the target.

4. Any general comments about the controllers?

   I have a high tendency to couple the roll commands into the joy stick whenever and try to command the wings-level turn. It is difficult to twist the joy stick about its longitudinal axis without putting in a slight amount of roll command. The bank angle, when added to the level turn, results in a nose low pitch attitude which then requires a good bit of control input to correct. It took about 5 runs to get to where I could command a wings-level turn without also commanding over ten degrees of bank. This coupling will cause major problems, especially in turbulence. I prefer the rudder pedal controller over this one.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 6 Date 26 Jan 1982

Controller and Task Thumb Button on Sidestick, Wings Level Turn Mode, Air-to-Ground Weapon Delivery

1. Was the controller useful for accomplishing the flight task?

   Yes. Much easier to make small flight path corrections using this controller than using basic flight controls

2. Did it feel natural to use the controller for the mode being controlled?

   Not really. It takes a bit of concentration in order to get used to performing a turn using the thumb controller

3. Can you foresee any problems in using these controllers in an operational environment?

   Yes. Airspeed changes during the maneuvering will cause (at least) longitudinal trim changes which cannot be balanced because the pilot is using his thumb to operate the controller.

4. Any general comments about the controllers?

   I liked this better than the twist controller, because at the lower force settings, it was much easier to command the wings-level turn without disturbing the bank angle of the aircraft. At the higher force settings, it required enough force to activate the controller that it was difficult, but not impossible, to put in turn commands without simultaneously putting in bank command. I preferred this over the twist grip controller, but still slightly prefer the pedals.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 7 Date 27 Jan 1983

Controller and Task Twist Grip Sidestick, Wings Level Turn Mode, Air-to-Ground Weapon Delivery

1. Was the controller useful for accomplishing the flight task?

   Yes - three functions with hand causes cross coupling for me - haven't compensated it out yet

2. Did it feel natural to use the cont ller for the mode being controlled?

   Yes - but not as natural as having controller on rudder pedals

3. Can you foresee any problems in using these controllers in an operational environment?

   If twist is applied and doesn't give satisfactory output, pilot will probably subconsciously apply rudder

4. Any general comments about the controllers?

   o Twist motion is somewhat unnatural
   o I wish my elbow didn't move around
   o I feel that almost 100% of the time I'm using more force than is necessary
   o Idea rudder pedals for large amplitude input, twist grip for fine corrections

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 6 Date 28 Jan 1983

Controller and Task One-Half Inch and Two Inch Rudder Pedals, Wings Level Turn Mode, Air-to-Ground Weapon Delivery

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes - fits in more with normal control of the rudder pedals

3. Can you foresee any problems in using those controllers in an operational environment?

   No

4. Any general comments about the controllers?

   The longer throw (± 2" about neutral) was difficult to control because it was difficult to stop the pipper on the target. The quickest way (theoretically) to acquire the target is to use full scale control deflection and release completely at a lead point which will approximately three times the time constant (3 x τ). However, when using the long throw of the rudder pedals, it is extremely difficult to quickly zero out the rudder input, so it is hard to stop the sight on the target the first time. This necessitates two or three more pedal inputs to finally align the sight on the target. With the shorter pedal travel, it is easier to release the pedal input and realign the pedals, neutralizing the command input. As long as the "pedals aligned" position corresponds to no turn rate, the easiest way to realign the pedals is to release them completely. In fact, in no wind/no turbulence conditions, once the target is acquired, I just left the pedals alone and the aircraft maintained the target for me until the end of the run.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 7 Date 28 Jan 1983

Controller and Task Thumb Button on Sidestick, Wings Level Turn Mode, Air-to-Ground Weapon Delivery

1. Was the controller useful for accomplishing the flight task?
   Yes but less useful than rudder or twist grip,seems unnatural way to grip a stick

2. Did it feel natural to use the controller for the mode being controlled?
   No - numerous times during flight had to consciously think to use my thumb; this didn't occur with twist or rudder - frequently adjusted grip on side stick to emphasize one axis or another

3. Can you foresee any problems in using these controllers in an operational environment?
   Not as good as others but could be used

4. Any general comments about the controllers?
   - Fine acquisition task once locked on
     - Seemed easy to maintain with rudder pedal controller
     - More difficult with twist
     - Most difficult with isometric
   - Bad - tended to separate axis, would make a pitch correction then make a sideforce correction; not both corrections simultaneously

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 8 Date 2 Feb 1983

Controller and Task Two Inch Rudder Pedals, Wings Level Turn Mode, Air-to-Ground Weapon Delivery

1. Was the controller useful for accomplishing the flight task?

   Rudder pedal for wings level turn is natural. Should use some control in the horizontal plane

2. Did it feel natural to use the controller for the mode being controlled?

   Yes, using rudder for yaw is natural

3. Can you foresee any problems in using these controllers in an operational environment?

   How to transfer to a fancy aircraft from conventional aircraft, if it makes any difference

4. Any general comments about the controllers?

   The rudder is the logical selection for horizontal movement

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 8 Date 4 Feb 1983

Controller and Task One-Half Inch Rudder Pedals, Wings Level Turn Mode, Air-to-Ground Weapon Delivery

1. Was the controller useful for accomplishing the flight task?

   Yes - use rudder for horizontal motion

2. Did it feel natural to use the controller for the mode being controlled?

   Yes

3. Can you foresee any problems in using these controllers in an operational environment?

   No

4. Any general comments about the controllers?

   Appears to be natural

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 9 Date 4 Feb 1983

Controller and Task One-Half Inch and Three Inch Rudder Pedals, Azimuth Pointing Mode, Air-to-Ground Weapon Delivery

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes

3. Can you foresee any problems in using these controllers in an operational environment?

   Either too small a rudder travel or too light a rudder force gradient complicates stability of the aircraft on the target

4. Any general comments about the controllers?

   One Half Inch δ_R Throw - Very objectionable, it led to perceived high F_R gradients and tendency to over or under control with little feedback to correct successive runs. This seemed to degrade the visual sensing of appropriate or needed aircraft translation and pointing, thus not allowing me to stabilize on the target. With multiple targets, the whole task could not be consistently completed.

   Three Inch δ_R Throw - Seemed tactily right; this throw was consistent with my visual perception or cues needed to maneuver through each of four targets. It, also, better highlighted the variations in F_R gradients and helped me distinguish a "best" gradient allowing me to be smoother and more exact in my aircraft pointing tasks. With a good F_R gradient (medium to higher) I believe my pointing stability produced minimal rating of the bullets; believe I would have had good shot grouping/patterns.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 8 Date 8 Feb 1983

Controller and Task Two Inch Rudder Pedals, Azimuth Pointing Mode, Approach and Landing

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes

3. Can you foresee any problems in using these controllers in an operational environment?

   Yes - you have taken the normal use of the rudders away. I use the rudder to control small amounts of yaw - with this system I have only aileron to control yaw.

4. Any general comments about the controllers?

   The pointing task is no problem. The runway alignment is a problem. Suggest you use a 1 mile final and start with proper crab as an initial condition.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 10 Date 9 Feb 1983

Controller and Task One-Half Inch, Two Inch and Three Inch Rudder Pedals, Azimuth Pointing Mode, Air-to-Ground Weapon Delivery

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes

3. Can you foresee any problems in using these controllers in an operational environment?

   No

4. Any general comments about the controllers?

   I thought the tasks with the smaller deflections were easier to control. I also preferred the higher forces coupled with any of the deflections.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 10 Date 10 Feb 1983

Controller and Task Three Inch Rudder Pedals, Azimuth Pointing Mode, Air-to-Ground Weapons Delivery

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes

3. Can you foresee any problems in using these controllers in an operational environment?

   No

4. Any general comments about the controllers?

   I did not care for the large displacements required to move the nose. They tended to cause a slight overcontrolling due to lack of feel for how much displacement to use.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 10 Date 10 Feb 1983

Controller and Task Thumb Button on Sidestick, Azimuth Pointing Mode, Air-to-Ground Weapon Delivery

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Not really

3. Can you foresee any problems in using these controllers in an operational environment?

   Yes lateral PIO tendency difficult to overcome

4. Any general comments about the controllers?

   Movement left tended to cause a left roll due to motion of hand. Not as natural feeling as rudder pedal control.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 10 Date 11 Feb 1983

Controller and Task Twist Grip Sidestick, Azimuth Pointing Mode, Air-to-Ground Weapon Delivery

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   No - interferes with roll motion slightly. Deadband helped considerably to mask this, making it more natural feeling.

3. Can you foresee any problems in using these controllers in an operational environment?

   No, as long as deadband is in.

4. Any general comments about the controllers?

   Certain configurations were affected by trigger motion, i.e. pulling nose off target.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 12 Date 25 Feb 1983

Controller and Task Two Inch and Three Inch Pedals, Wings Level Turn Mode, Approach and Landing

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Not at first. Once I saw what response it would give it seemed a bit more natural.

3. Can you foresee any problems in using these controllers in an operational environment?

   Provided the pilot remembers what happens, no. A problem may occur at first on transition to an aircraft that can use this controller.

4. Any general comments about the controllers?

   It felt unusual to see the runway "SIDEWAYS" (out the 'corner' of the windscreen) without the wings banked and holding a ton of crosswind control. Other than that, it was a blast to fly.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 12 Date 28 Feb 1983

Controller and Task One-half Inch Rudder Pedals, Wings Level Turn Mode, Approach and Landing

1. Was the controller useful for accomplishing the flight task?

   Yes, especially when pedal force allowed more concentration on the runway.

2. Did it feel natural to use the controller for the mode being controlled?

   Yes

3. Can you foresee any problems in using these controllers in an operational environment?

   Only on long approaches. I feel the pilot will have to consciously relax to avoid "Stiff Legs" from the short pedal throw.

4. Any general comments about the controllers?

   With this displacement and the lighter to medium pedal forces, it was easier to "Think" the airplane to the touchdown point. Much like "Thinking" a rifle shot to the bulls eye. The heavier pedal forces proved a mild distraction but no great hindrance to overall task performance. Since the turbulence was low, the landing task was not very violent. Versus a T-38, this was a lot easier for this type of correction (small offsets, short final) because of no need to get the wings out of level and as a result eyeball roll lead points etc.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 13 Date 1 Mar 1983

Controller and Task Two Inch Rudder Pedals, Wings Level Turn Mode, Approach and Landing

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes, the use of rudders to yaw about the directional axis is very natural - the next logical step for positioning the nose.

3. Can you foresee any problems in using these controllers in an operational environment?

   No

4. Any general comments about the controllers?

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 14 Date 1 Mar 1983

Controller and Task One-Half Inch Rudder Pedals, Wings Level Turn Mode, Approach and Landing

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes, some tendency to use roll control but this was easily overcome.

3. Can you foresee any problems in using these controllers in an operational environment?

   Probably not but some consideration should be given to braking heavily on touchdown - the force/displacements that are good during final touchdown may not work during rollout if both braking and directional control are required.

4. Any general comments about the controllers?

   Use of rudder only for turning is good and I quickly adapted to its use. Using one controller instead of two (roll and yaw) is an improvement.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 13 Date 2 Mar 1983

Controller and Task Twist Grip Sidestick, Wings Level Turn Mode,

Approach and Landing

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   No. Too much of a tendency to use as an On/Off switch, especially for wrist movements away from the body centerline HAND (RIGHT) FOREARM

3. Can you foresee any problems in using these controllers in an operational environment?
   Yes, if a blended turn is tried i.e. use of both aileron + rudder together, a tendency was to force the nose to hunt in a small dutch roll type motion. If either twist or side force was used independently, no problem.

4. Any general comments about the controllers?

   Once a full deflection twist reference had been established, it was a lot easier to judge an input to the controller. However, if not enough reaction was achieved, the tendency was to grip it hard + really force it over. This effectively overloaded the pressure receptors of the hand making precise control difficult at best. (White Knuckle Flying) once a conscious effort to move and not tighten up, even on large inputs, control improved. However the twist in itself still was imprecise to a degree.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 12 Date 3 Mar 1983

Controller and Task Thumb Button on Sidestick, Wings Level Turn Mode, Approach and Landing

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes

3. Can you foresee any problems in using these controllers in an operational environment?

   Only if the response is such that the pilot has to grip the stick tightly in order to get the desried performance.

4. Any general comments about the controllers?

   1. General tendency was to use the thumb button as an on/off switch. Was great to fine tune the approach.

   2. Was a convenient way to align the aircraft. Much easier than using the wings.

   3. On the vertical/twist throttle. General tendency was to forget it as attention was devoted to the landing.

   Order of Preference

   1. Rudder pedal

   2. Button

   3. Twist grip

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 13 Date 3 Mar 1983

Controller and Task Twist Grip Sidestick, Wings Level Turn Mode, Approach and Landing

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes, provided enough pilot practice was accomplished

3. Can you foresee any problems in using these controllers in an operational environment?

   No

4. Any general comments about the controllers?

   The lack of control displacement feedback was annoying. As with other movements of the stick a comparable movement in the twist mode would give the controller a more natural feel. My only fear with using the stick to translate the nose by twisting vs using the rudders is that too much control functions are performed by the right hand. The input of rudders allow the pilot to concentrate on pitch/roll with his hand.

   The Vertical Translation (Twist Throttle) is a good control addition. Using it in the flow as you retard the throttle to idle feels natural.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 12 Date 4 Mar 1983

Controller and Task Two Inch Rudder Pedals, Azimuth Pointing Mode, Approach and Landing

1. Was the controller useful for accomplishing the flight task?

   yes

2. Did it feel natural to use the controller for the mode being controlled?

   yes

3. Can you foresee any problems in using these controllers in an operational environment?

   Only with respect to learning how much to use and when. Also, for a changing input to correct drifts, difficult to judge rudder necessary.

4. Any general comments about the controllers?

   Much more natural feeling than the lateral translation. Especially if a set crosswind was experienced, easy to set crab and then kick it out.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 12 Date 4 Mar 1983

Controller and Task

Twist Grip Sidestick, Azimuth Pointing Mode, Approach and Landing

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes

3. Can you foresee any problems in using these controllers in an operational environment?

   Yes, touchy to use. Also, very easy to twist grip especially when small changes needed down close.

4. Any general comments about the controllers?

   Two inputs at once difficult to estimate. Example, bank to kill drift then twist to get nose around. If both tried together down close, difficult to get both correct.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 12 Date 4 Mar 1983

Controller and Task One-Half Inch and Two Inch Rudder Pedals, Lateral Translation Mode, Approach and Landing

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   No! Inputs were backwards from "normal" aircraft and were uncomfortable to get use to.

3. Can you foresee any problems in using these controllers in an operational environment?

   Yes! Extreme confusion on difficult approaches especially instruments.

4. Any general comments about the controllers?

   1. First set of pedals, right pedal, right force re crab-pedal force/stick coordination backwards from normal. Right pedal right stick, instead of left pedal right stick.

   2. Second set of pedals, left pedal right force taking crab out, pedal/stick coordination reversed left pedal left stick vs normal right pedal left stick.

   3. Vertical translation up & down stick very uncomfortable. Major tendency to A pull up in flare compounded adjustment of flight path to hit spot. Nice feature, could bounce aircraft at any time so hitting spot was not real hard.

      A PULL UP = Pull stick itself up. Flare motion is a pull back - since arm rests on a nice shelf, pulling up is real easy when wrist rotates.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 12 Date 4 Mar 1983

Controller and Task

Twist Grip Sidestick, Lateral Translation, Approach and Landing

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes

3. Can you foresee any problems in using these controllers in an operational environment?

   Yes, when bank was required as well as twist, hard to judge amount.

4. Any general comments about the controllers?

   Force required to twist again conflicted with feel close to ground. Also, on cases where wind cranked around close to ground, force required to twist took alot of "feel" out of hand.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 14 Date 4 Mar 1983

Controller and Task Two Inch Pedals, Lateral Translation Mode, Approach and Landing

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   No - although I was not confused as to function of the controller, it is adverse to normal wing low technique

3. Can you foresee any problems in using these controllers in an operational environment?

   Possibly, proper training and practice would be very important to insure consistent safe use

4. Any general comments about the controllers?

   Not enough runs flown to fully integrate the effect of the controller into the task. Once the effort of the controller is fully understood, then the controller would be useful to eliminate crab on touchdown.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 14 Date 7 Mar 1983

Controller and Task One-Half Inch Rudder Pedals, Lateral Translation Mode, Approach Landing

1. Was the controller useful for accomplishing the flight task?

   Not always -

2. Did it feel natural to use the controller for the mode being controlled?

   Only when β was controlled with roll and kept in the correct place -

3. Can you foresee any problems in using these controllers in an operational environment?

   Yes, no way to control the nose - if the pilot kills the x-wind with roll to a crab angle, then there is no way to move the nose.

4. Any general comments about the controllers?

   Using this controller for the task presented resulted in some confusing situations (i.e. landing with the nose to the right with a left x-wind). I think this could result in a really degrading situation in a more dynamic environment.

   I preferred the 1/2" pedal travel to the 2" travel. Main reason is harmony with the side-stick controller - with a center stick, the 2" might be better.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 12 Date 8 Mar 1983

Controller and Task Two Inch Rudder Pedals, Wings Level Turn Mode, Approach and Landing

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes

3. Can you foresee any problems in using these controllers in an operational environment?

   Only in situations where rudder pedal force precludes precise control due to lack of feel.*

4. Any general comments about the controllers?

   I preferred this over the twist grip. Larger inputs were easier to judge and control, especially down close in the flare.

   While this task with turbulence was an increase in workload, it wasn't to such a degree as to make the task difficult.

   Turbulence a good moderate type, no real hindrance to task performance although workload was increased somewhat.

*For extreme control gradients (i.e. too light or too heavy).

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 12 Date 8 Mar 1983

Controller and Task

Twist Grip Sidestick, Wings Level Turn Mode, Approach and Landing

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes

3. Can you foresee any problems in using these controllers in an operational environment?

   Yes, especially if blended inputs are required. Also, if the controller is set so hard as to require a definite, hard twist, I'd rather use the ailerons.

4. Any general comments about the controllers?

   Because blended control would seem to be difficult, I tended to use this controller either to turn side to side or in pitch. Hardly ever both at once.

   If the control was set too sensitive, precision control again down in the flare was difficult due to a tendency to over control.

   Turbulence a good moderate type, no real hindrance to landing task. This controller slightly less precise than rudder pedals.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 14 Date 8 Mar 1983

Controller and Task One-Half Inch and Two Inch Rudder Pedals, Azimuth Pointing Mode, Approach and Landing

1. Was the controller useful for accomplishing the flight task?

   Yes, especially with 2" RP

2. Did it feel natural to use the controller for the mode being controlled?

   Yes

3. Can you foresee any problems in using these controllers in an operational environment?

   No

4. Any general comments about the controllers?

   Did not like 1/2" RP - mostly due to loss of response predictability - a larger force may lessen this -

   2" RP was very predictable, quickly adapted to taking out the crab at touchdown -

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 12 Date 11 Mar 1983

Controller and Task Left Hand Operated Thumbwheel, Wings Level Turn Mode, Approach and Landing

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes - see A

3. Can you foresee any problems in using these controllers in an operational environment?
   Yes, with a tendency toward confusion as to which side of the wheel gave what response.

4. Any general comments about the controllers?

   A Top View

   
   Thumb Location

As long as I left the thumb as shown, a forward movement meant left, the opposite right. All OK. Slight mental lapses occurred if the thumb was placed opposite.

As a preference, I would choose this over the twist grip. I would prefer the rudder pedals over this controller due to the absence of a tendency to confuse directions.*

*Not "bomb proof" as is - i.e. could put thumb on other side of wheel and reverse polarity - maybe mount wheel as 

Note: Rudder pedal and TGSSC comments - NC from 3/9/83.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 14 Date 11 Mar 1983

Controller and Task

Left hand operated Thumbwheel, Wings Level Turn Mode, Approach and Landing

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   No, not all the time.

3. Can you foresee any problems in using these controllers in an operational environment?

   Yes, in its present setup it can be confusing as to which motion of the thumb yields what response.

4. Any general comments about the controllers?

   The wheel concept would be improved it if were set-up such that the movement required is a simple left right movement of the thumb. This would make the motion similar to a trim button.

Order at preference: Rudders
Thumb wheel
Twist grip - I did not like the twist grip finding it physically uncomfortable

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 21 Date 18 July 1983

Controller and Task Two Inch Rudder Pedals, Wings Level Turn Mode, Air-to-Air Tracking

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes

3. Can you foresee any problems in using these controllers in an operational environment?

   No

4. Any general comments about the controllers?

   Excellent response and feel.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 22 Date 18 July 1983

Controller and Task Two Inch Rudder Pedals, Wings Level Turn Mode, Air-to-Air Tracking

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes

3. Can you foresee any problems in using these controllers in an operational environment?

   No

4. Any general comments about the controllers?

   None

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 21 Date 19 July 1983

Controller and Task Three Inch Rudder Pedals, Wings Level Turn Mode, Air-to-Air Tracking

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes

3. Can you foresee any problems in using these controllers in an operational environment?

   No

4. Any general comments about the controllers?

   I prefer the shorter-throw pedals, which appear more sensitive.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 22 Date 19 July 1983

Controller and Task Two Inch Rudder Pedals, Wings Level Turn Mode, Air-to-Air Tracking

1. Was the controller useful for accomplishing the flight task?

   Yes - I think this is a great improvement for the fine tracking task.

2. Did it feel natural to use the controller for the mode being controlled?

   Yes - easy to adapt to

3. Can you foresee any problems in using these controllers in an operational environment?

   No - easy to use for a pilot who likes to use rudders - lot like using a rudder with much less lag

4. Any general comments about the controllers?

   I'll trade my rudder pedals in any day

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 22 Date 20 July 1983

Controller and Task Twist Grip Sidestick, Wings Level Turn Mode, Air-to-Air Tracking

1. Was the controller useful for accomplishing the flight task?

   Yes, I think; however, I'm not sure my results are better than with the ordinary aircraft.

2. Did it feel natural to use the controller for the mode being controlled?

   Yes - but not as natural as with rudder pedals - more difficult to

3. Can you foresee any problems in using these controllers in an operational environment?

   Wrist fatigue

4. Any general comments about the controllers?

   - On the couple of runs where I didn't use the controller I believe that it was zero deflection. This is different than results with rudder pedal controller where I would hold a set deflection and not make rudder pedal corrections.
   - I felt the sideforce motions more today.
   - I felt my corrections were more discrete today. I would make a bank correction and then follow that with a twist correction. I was able to make bank and azimuth corrections simultaneously.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 21 Date 21 July 1983

Controller and Task Twist Grip Sidestick, Wings Level Turn Mode, Air-to-Air Tracking

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes, except need better shape for torque or twisting

3. Can you foresee any problems in using these controllers in an operational environment?

   No

4. Any general comments about the controllers?

   In 2g turn, once I became disoriented, and it was unnatural for me to use the twist, bank and pull to get back.

   After a few more tries this disorientation went away, and the flying became much more natural. Neat system!

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 22 Date 21 July 1983

Controller and Task Two Inch Pedal, Wings Level Turn Mode, Air-to-Air Tracking

1. Was the controller useful for accomplishing the flight task?

   Yes - very

2. Did it feel natural to use the controller for the mode being controlled?

   Yes for any pilot who uses rudder pedals a lot

3. Can you foresee any problems in using these controllers in an operational environment?

   None

4. Any general comments about the controllers?

   I can make bank and yaw corrections simultaneously with pedal controller-can't with twist grip.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 21 Date 22 July 1983

Controller and Task One Inch Rudder Pedals, Wings Level Turn Mode, Air-to-Air Tracking

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes

3. Can you foresee any problems in using these controllers in an operational environment?

   No

4. Any general comments about the controllers?

   Flew with thumb on thumb button. Seems to be more natural. Banks are not difficult with thumb on button.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 21 Date 22 July 1983

Controller and Task Thumb Button on Sidestick, Wings Level Turn Mode, Air-to-Air Tracking

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes

3. Can you foresee any problems in using these controllers in an operational environment?

   No

4. Any general comments about the controllers?

   Most relaxing method yet, compared to rudder or twist.
   Most natural feeling after a couple of tries.
   Turning targets noticeably easier to track with thumb button.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 22 Date 22 July 1983

Controller and Task Thumb Button on Sidestick, Wings Level Turn Mode, Air-to-Air Tracking

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes - but not as natural as the rudder pedal controller - but more natural than twist grip

3. Can you foresee any problems in using these controllers in an operational environment?

   No

4. Any general comments about the controllers?

   - I found my most effective thumb position was with the tip of my thumb on the button. I also tried middle of last thumb bone and joint of thumb in dimple of button.

   - Had same problem as twist grip in making simultaneous corrections with button and side stick.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 22 Date 25 July 1983

Controller and Task Twist Grip Sidestick, Wings Level Turn Mode, Air-to-Air Tracking

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes

3. Can you foresee any problems in using these controllers in an operational environment?

   No

4. Any general comments about the controllers?

   My opinion of this controller has increased significantly.

   The difference between the controllers have become too subtle for me to tell the difference while accomplishing this task.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 21 Date 26 July 1983

Controller and Task Twist Grip Sidestick, Wings Level Turn Mode, Air-to-Air Tracking

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes

3. Can you foresee any problems in using these controllers in an operational environment?

   No

4. Any general comments about the controllers?

   Controller felt more natural in twist. Still think the controller could be redesigned for the twisting motion. I believe it is easier to fly without the motion. Without the motion it is really difficult to distinguish between the different conditions.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 21 Date 22 Aug 1983

Controller and Task

Twist Grip Sidestick, Wings Level Turn Mode, Air-to-Air Tracking

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes

3. Can you foresee any problems in using these controllers in an operational environment?

   No

4. Any general comments about the controllers?

   Last session no motion. With motion this time it was easier to distinguish good and bad. Some of the modes were so good this time I used a rating of 1. This didn't leave me anywhere to go when I saw something better. Therefore, the next time I saw something really good I gave it a 2, but finally decided to go with a 1 because it was very good.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 23 Date 22 Aug 1983

Controller and Task

Twist Grip Sidestick, Wings Level Turn Mode, Air-to-Air Tracking

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes

3. Can you foresee any problems in using these controllers in an operational environment?

4. Any general comments about the controllers?

   I occasionally found myself trying to use the rudder pedals instead of the twist grip in order to get a "Solution". I did like the grip, however.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 21 Date 23 Aug 1983

Controller and Task

Thumb Button on Sidestick, Wings Level Turn Mode, Air-to-Air Tracking

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes

3. Can you foresee any problems in using these controllers in an operational environment?

   No

4. Any general comments about the controllers?

   More difficult to tell difference in modes with the turbulence. But it really wasn't more difficult to control. Turbulence provided more realism to task, made me work or concentrate harder with turbulence.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 23 Date 23 Aug 1983

Controller and Task Thumb Button on Sidestick, Wings Level Turn Mode, Air-to-Air Tracking

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes - sort of

3. Can you foresee any problems in using these controllers in an operational environment?

   No

4. Any general comments about the controllers?

   With most configurations, I had a tendency to over control - PIO. Also, I would occasionally move my thumb around which complicated matters greatly.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 21 Date 24 Aug 1983

Controller and Task Twist Grip Sidestick, Wings Level Turn Mode, Air-to-Air Tracking

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes

3. Can you foresee any problems in using these controllers in an operational environment?

   No

4. Any general comments about the controllers?

   Twist felt just as good as button or was just as controllable as button in turbulence.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 23 Date 24 Aug 1983

Controller and Task Two Inch Rudder Pedals, Wings Level Turn Mode, Air-to-Air Tracking

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes

3. Can you foresee any problems in using these controllers in an operational environment?

   No

4. Any general comments about the controllers?

   I prefer the pedals to the other controllers -

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 23 Date 24 Aug 1983

Controller and Task Two Inch Rudder Pedals, Wings Level Turn Mode, Air-to-Air Tracking

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes

3. Can you foresee any problems in using these controllers in an operational environment?

   No

4. Any general comments about the controllers?

   All in all, I liked the controller - still a tendency to overshoot back and forth on the target though. I was using my entire leg to control though. Size 15 feet probably didn't help though.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 21 Date 25 Aug 1983

Controller and Task Two Inch Rudder Pedals, Wings Level Turn Mode, Air-to-Air Tracking

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes

3. Can you foresee any problems in using these controllers in an operational environment?

   No

4. Any general comments about the controllers?

   Use toes on pedals, instead of leg motions. Engine noise today was effective, it made turbulence more realistic. You didn't hear all the machinery noise. I feel more precise tracking can be accomplished using button or twist grip, vs today's pedal inputs.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 21 Date 26 Aug 1983

Controller and Task Thumb Button on Sidestick, Wings Level Turn Mode, Air-to-Air Tracking

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes

3. Can you foresee any problems in using these controllers in an operational environment?

   No

4. Any general comments about the controllers?

   I like button. Last day, my preference on controllers was:

   1. Button
   2. Twist
   3. Rudder

   Button gave me a feeling of direct line between thumb and reticle, and the configurations used made it fairly easy to hold on target, even with the simulated turbulence.

CONTROLLER USEFULNESS QUESTIONNAIRE

Pilot Code 23 Date 26 Aug 1983

Controller and Task One Inch and Three Inch Rudder Pedals, Wings Level Turn Mode, Air-to-Air Tracking

1. Was the controller useful for accomplishing the flight task?

   Yes

2. Did it feel natural to use the controller for the mode being controlled?

   Yes

3. Can you foresee any problems in using these controllers in an operational environment?

   No.

4. *Any general comments about the controllers?*

   I still like the foot pedals best. I preferred the 2" displacement to the 1" or 3".

   Preference for controllers is:

   1. Pedals (2" displacement)
   2. Twist
   3. Button

   With turbulence and twist grip I preferred configurations which allowed me to get back on target as quickly as possible after being jolted off.

APPENDIX G
POST-SIMULATION DEBRIEFING QUESTIONNAIRE

This questionnaire was provided to allow the pilots participating in this simulation to officially present their comments and opinions on the simulation test in general. The questions were structured to jog the pilot's memory on the various aspects of the simulation. Note that the answers to question three are based only on limited exposure to turbulence in the air-to-ground pilot comments. Turbulence was not included in the task, however during the development of the model, the pilots were asked to comment on its realism based on one or two practice runs.

The responses of seven pilots are included in this appendix. Unfortunately, due to the somewhat random scheduling, several pilots did not complete this form. A review of the comments during the simulation and on the controller usefulness questionnaires indicates that their conclusions would be similar to those presented here.

SIMULATION COMMENTS
PILOT CODE 1
AIR-TO-GROUND, WINGS LEVEL TURN

1. Was the simulation task realistic from a combat mission standpoint? Do you have any suggestions?

   Yes. Would like to see a moving target.

2. Do you have any comments on the displays, i.e., target projection on the screen, out-the-window view? How could the display be improved?

   The display is not very detailed - the sky is not realistic. Use more light/better projection.

3. Was the turbulence effect realistic?

   Not observed.

4. Did you have any comments on the briefing, training, amount of familiarization time, test procedures, test conduction, etc.? What changes would you recommend?

   None - I would like to use half ratings when using the Cooper-Harper scale.

5. Did you get fatigued or bored in the simulator such that it could have affected your ratings? What changes in procedure could eliminate this condition?

   Sometimes I get fatigued due to a particular controller configuration - does not affect rating.

6. Other general comments on the simulation.

   I like the wings level turn mode. My preference in controllers: Rudder, grip, and isometric switches.

SIMULATION COMMENTS
PILOT CODE 6
AIR-TO-GROUND, WINGS LEVEL TURN

1. Was the simulation task realistic from a combat mission standpoint? Do you have any suggestions?

   It seemed to be realistic. Not being a fighter pilot, I am not qualified to rate the procedures, but the task was, I am sure, representative of their procedures.

2. Do you have any comments on the displays, i.e., target projection on the screen, out-the-window view? How could the display be improved?

   The horizon line only worked one day of my five. Even with the seat full up, I had a hard time seeing the HUD horizon line, so I had a difficult time maintaining wings-level on the 20° pull-up.

3. Was the turbulence effect realistic?

   If anything, it was a little too light. At 520 kts, 500-1000 at AGL over plowed fields/woods/roads, there will be a lot of turbulence due to convective action.

4. Did you have any comments on the briefing, training, amount of familiarization time, test procedures, test conduction, etc.? What changes would you recommend?

   I would have like to try a different procedure, such as air-to-air. I did the same strafing run all week. It would have been fun to at least try the bombing or air-to-air.

5. Did you get fatigued or bored in the simulator such that it could have affected your ratings? What changes in procedure could eliminate this condition?

   No.

6. Other general comments on the simulation.

   I liked the pedals best, the isometric second (only slightly less). The twist grip was a distant third. It is difficult to use and unnatural to command. It's almost impossible to force it to twist without inducing some bank commands. The rudders on short throw seemed to be the easiest to use and control.

SIMULATION COMMENTS

PILOT CODE 8

AIR-TO-GROUND, WINGS LEVEL TURN

1. Was the simulation task realistic from a combat mission standpoint? Do you have any suggestions?

   No fighter combat experience.

2. Do you have any comments on the displays, i.e., target projection on the screen, out-the-window view? How could the display be improved?

   Limited field of view.

3. Was the turbulence effect realistic?

   None.

4. Did you have any comments on the briefing, training, amount of familiarization time, test procedures, test conduction, etc.? What changes would you recommend?

   More clarity on exact task.

5. Did you get fatigued or bored in the simulator such that it could have affected your ratings? What changes in procedure could eliminate this condition?

   One and one-half hours about the limit.

6. Other general comments on the simulation.

   Excellent supervision - would like to see the other control modes.

SIMULATION COMMENTS
PILOT CODE 9
AIR-TO-GROUND, WINGS LEVEL TURN

1. Was the simulation task realistic from a combat mission standpoint? Do you have any suggestions?

   Yes.

2. Do you have any comments on the displays, i.e., target projection on the screen, out-the-window view? How could the display be improved?

   Sky-earth horizon didn't seem to degrade our investigation when it failed.

3. Was the turbulence effect realistic?

4. Did you have any comments on the briefing, training, amount of familiarization time, test procedures, test conduction, etc.? What changes would you recommend?

   Fine, wouldn't suggest change.

5. Did you get fatigued or bored in the simulator such that it could have affected your ratings? What changes in procedure could eliminate this condition?

   1 hour plus in the box was refreshing. 1 hour 30 minutes in the box was the point where boredom/fatigue began.

6. Other general comments on the simulation.

SIMULATION COMMENTS
PILOT CODE 10
AIR-TO-GROUND, WINGS LEVEL TURN

1. Was the simulation task realistic from a combat mission standpoint? Do you have any suggestions?

   Yes.

2. Do you have any comments on the displays, i.e., target projection on the screen, out-the-window view? How could the display be improved?

   Visual system needs improving by increasing resolution (Better Focus).

3. Was the turbulence effect realistic?

   Yes.

4. Did you have any comments on the briefing, training, amount of familiarization time, test procedures, test conduction, etc.? What changes would you recommend?

   Nothing to improve.

5. Did you get fatigued or bored in the simulator such that it could have affected your ratings? What changes in procedure could eliminate this condition?

   No.

6. Other general comments on the simulation.

   Color visual projection would improve the simulation. It seems as if the super terrain model board is not being used to its true potential.

SIMULATION COMMENTS

PILOT CODE 21

AIR-TO-GROUND, WINGS LEVEL TURN

1. Was the simulation task realistic from a combat mission standpoint? Do you have any suggestions?

   The target could have moved around more in amplitude and quickness. The turbulence simulation helped to make tracking more difficult.

2. Do you have any comments on the displays, i.e., target projection on the screen, out-the-window view? How could the display be improved?

   No. I thought it was good.

3. Was the turbulence effect realistic?

   Yes, especially when we turned up engine noise which drowned out mechanical noise.

4. Did you have any comments on the briefing, training, amount of familiarization time, test procedures, test conduction, etc.? What changes would you recommend?

   I thought it was all very thorough.

5. Did you get fatigued or bored in the simulator such that it could have affected your ratings? What changes in procedure could eliminate this condition?

   Not at all. I thought the time allotted was just right and went by fast.

6. Other general comments on the simulation.

   Pretty good simulation.

SIMULATION COMMENTS

PILOT CODE 23

AIR-TO-GROUND, WINGS LEVEL TURN

1. Was the simulation task realistic from a combat mission standpoint? Do you have any suggestions?

   No, but realistic scenarios would offer little chance of evaluation. Sustained tracking is probably the best scenario.

2. Do you have any comments on the displays, i.e., target projection on the screen, out-the-window view? How could the display be improved?

   1. Real HUD

   2. Color presentation

   3. Brighter (Lighter?)

3. Was the turbulence effect realistic?

   Yes.

4. Did you have any comments on the briefing, training, amount of familiarization time, test procedures, test conduction, etc.? What changes would you recommend?

   No - all were adequate.

5. Did you get fatigued or bored in the simulator such that it could have affected your ratings? What changes in procedure could eliminate this condition?

   Yes. None.

   One hour is about all I could take "in the ball" at a time.

6. Other general comments on the simulation.

   Very enjoyable.

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